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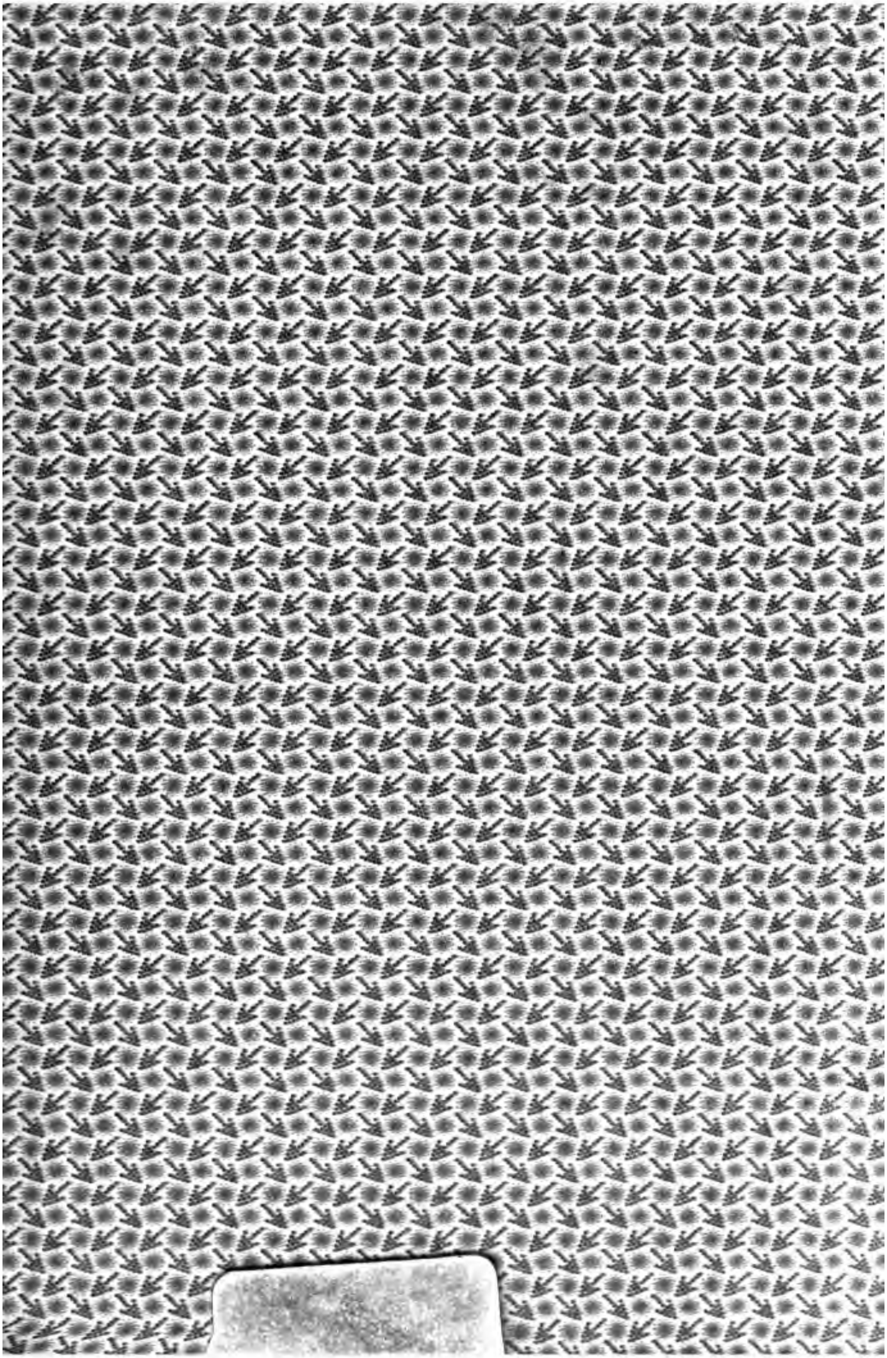

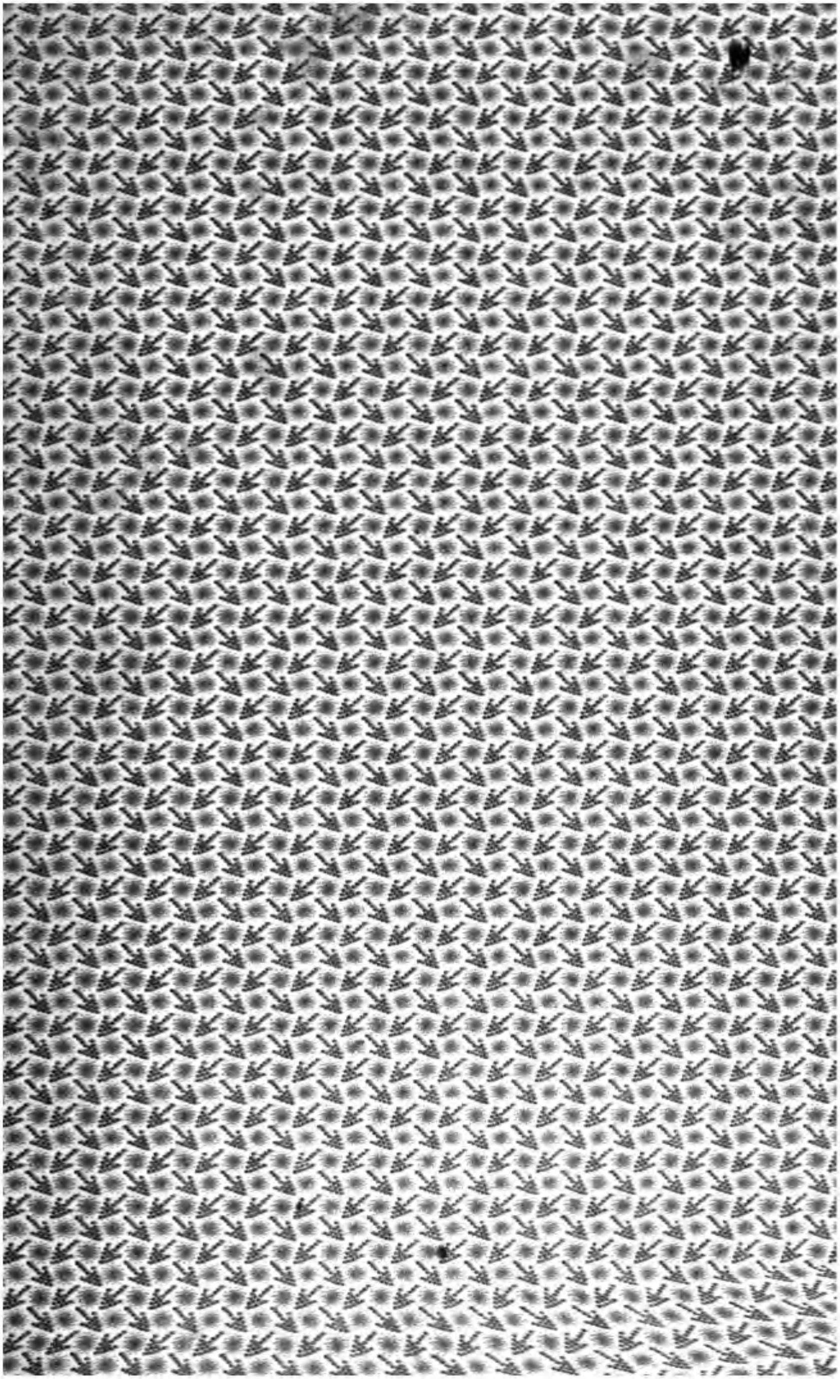

THE PRESENCE
OF
Organic Matter in Potable Water
ALWAYS
DELETERIOUS TO HEALTH;

TO WHICH IS ADDED,
The Modern Analysis.

BY
O'BRIEN MAHONY, L.R.C.P., ED.,
L.F.P.S., L.A.H., &c., &c.

SECOND EDITION, REVISED AND ENLARGED.

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Preface to Second Edition.

The utility and importance of Hygiene as a branch of scientific education is now almost universally recognised. Some acquaintance with its general laws and common facts is, in the present day, not only useful but necessary to professional persons, and advantageous in every sphere of life. The design of this Treatise is to furnish a short—yet connected and comprehensive—view of the special department selected, which may serve as an introduction to a more extended study of the whole. It is, however, hoped that it contains enough to show the student the richness of the domain entered upon, the attractive nature of some of the topics glanced at, and the great advantage to be derived from a full and perfect acquaintance with the entire subject.

Much as the writer may naturally feel pleased at the very flattering reception accorded to his first essay in this direction, it is not without diffidence that he ventures to respond to the call made upon him to thus—after a few months—write the preface of a second edition. At the same time this approbation brings with it the assurance that his past labours have been appreciated, and gives encouragement to hope that the additional improvements now introduced will be further favourably accepted.

In re-writing these pages he has been urged by the conviction that, to connect those facts which lie sterile and disjointed so long as they remain diffused or scattered, and assume importance only when connectedly or methodically arranged, are some of the, perhaps, most useful objects attainable by the publication of books,—and hence does he believe that this small volume will have its mission recognised.

In condensing the varied facts so profusely at his disposal he has guarded himself against adopting any system, but preferred giving due weight to certain opinions and prominence to theories clearly ascertained; those that may be thought probable, or even possible, have not been omitted, in the hope that the observative and reflective faculties of the learned may be awakened to the full import of the matters glanced at, with a view to an exhaustive investigation.

In detailing the analytic processes he has aimed at perspicuity—in selecting the most approved plan of procedure he trusts, by the introduction of slight modifications, to have simplified much which might have otherwise appeared complex and embarrassing to the student,—and in the arrangement the chief desire of the author has been to render the whole as practical as possible.

CLONMEL, *December*, 1869.

ERRATA.

At page 16, on the 11th line from the top, for "first" read "just." At page 18, on the 7th line, for "7" read "·7;" and on the 11th line, for "23·1 + 7 = 16·17" read "23·1 + ·7 = 1·617."

THE PRESENCE, &c.

Perhaps there is scarcely any topic entitled to greater consideration, in a sanitary point of view, than the state of purity of the potable water in cities and large towns; yet, notwithstanding its importance, it is rather remarkable that the subject has not previously engaged more of our attention. Being recently professionally employed in the examination of the purity of the supply of potable water to a neighbouring town, circumstances constrained me to extend the inquiry. Hence it is that I thus venture to place before the profession a brief digest of our present state of knowledge of the whole question; and beg to arrest attention more particularly to a few points of grave import, in reference to the physiological action and pathological effects of the habitual use as a diluent of water in which "organic matter" is held in solution.

It is not in every epoch that great discoveries are vouchsafed;—indeed it rarely, if ever, happens that any great gift or great advance in knowledge has directly resulted from the labours, however well directed, of any one individual,—it has almost invariably been brought about by the successive or combined action, for a series of years, of many. To the discussions in scientific societies are we greatly indebted that errors are exposed, some fallacies detected, some principles re-investigated, and thus is it that a clearer conception of questions deemed abstruse result in demonstration. In reference to the modern analysis of water, Frankland, Armstrong, Miller, Smith, Wanklyn, Chapman, and others have rendered good service in their large, their honest criticisms; and, by a process of what we may call reconstruction and repair, the whole edifice has, at their hands, undergone an admirable revision.

Until very recently chemists were not accustomed, in the analysis of potable water, to take into consideration the presence, in any excessively minute quantities, of the heavy metals—arsenic, copper, iron, lead, manganese, and zinc. At the present time the mere existence of microscopic quantities of these metals in solution is attracting attention. It is found, when taken internally for some long time, that metallic impregnations are cumulative; it is held by men of acute observation that the physiological action of minute traces of metals in potable water is often sufficient to determine the sanitary condition of the inhabitants of a country; and that possibly "a part of the sanitary effect of what is called 'change of air' is due solely to change in the minute metallic impurity in the drinking water of the district which is visited." Hence it becomes, for all future time, indispensable to conduct a water analysis with extended views of what deleterious impregnations imply.

Although the efficacy of water, variously applied in the cure of several diseases, is, in the present day, an admitted fact, yet it has not been permitted into the list of materia medica of the British Pharmacopœia, either in the state in which it usually presents, as common water, or in that other natural state in which it holds in solution substances which impart to it new properties capable of inducing certain actions in the animal system, and is called mineral water. The medical practitioner is expected to know the qualities and effects of water under both of these forms; and he is assumed to be conversant with the mode of conducting its analysis. It is satisfactory to observe that in the present day more enquiry is being specially directed to the subject; and we should say that perhaps no one of the correlative sciences within the domain of medicine is, just now, more diligently and usefully cultivated than is the general question of Hygiene.

Owing to its great solvent powers, water—which is almost universally diffused over the surface of our globe—is not found *perfectly* pure in any place. In some mountainous and mining districts it holds in solution minute traces of the heavy metals. It frequently obtains, in cities and large towns whose water supply is procured from street pumps, impurities from the soil, from sewage, from house drainage, as well as from intramural burial grounds, and other channels of a like nature. In general, however, the impregnations acquired are not sufficient to give to it any very sensible taste or odour to render it unfit for ordinary domestic purposes; and this is the state in which we usually obtain common water. The purity of water greatly depends upon the source whence it is derived, and whether it has, in its course, been exposed or not to the purifying action of light and air. The varieties of common water present themselves in the following order:—

First—Rain Water.
Second—Spring Water.
Third—Well or Pump Water.
Fourth—River Water.

Rain Water is, of course, the purest of all natural water—its specific gravity is nearly equal to that of distilled water. It, however, is found to contain more oxygen; and when collected in large towns, or from off the roofs of houses, it acquires impurities from soot, from the droppings of birds, and from other causes. It has further been remarked that snow-water, when recently melted, is free from atmospheric air, and that hence fish cannot live in it; but, on exposure for some time to the atmosphere, it regains its air, and then it possesses the same qualities as rain water.

Spring Water, which rises through sand or gravel, and at a *small depth* from the surface, is usually nearly as free from impurities as rain water. It, however, may contain traces of very minute proportions of soda, lime, magnesia, hydrochloric acid, and carbonic acid, not in quantity sufficient to render it unfit for drinking purposes.

Well or *Pump Water*, which may be held to be spring water, obtained from a *considerable depth*, is always more impure than that at or near the surface. It generally contains some earthy salts, and much carbonic acid. Owing to its holding in solution salts of lime, magnesia, soda, it is found not to dissolve soap, which is the characteristic of hard water.

River Water, which passes rapidly over a rough, pebbly, or silicious channel, is frequently as free from impurities as the purest spring water; but when it passes smoothly and slowly over a *clayey stratum* it assumes the nature and qualities of pump water. Occasionally river water contains much "organic matter" in solution, doubtless the result of the decomposition of animal and vegetable substances casually having found their way into it; and this is very generally the case with that obtained from lakes and marshes.

In conducting the analysis of water for sanitary purposes, the objects to be ascertained are:—

1st—Its source.
2nd—The quantity of solids held in solution.
3rd—The hardness, temporary or otherwise.
4th—The presence of the mineral acids and of chlorine.
5th—The presence of nitrogenous organic matter.
6th—The heavy metals.

The determination of the total solids held in solution is a very easily accomplished process:—Take 70 c.c. of the water, and pour it into a flask previously cleansed, dried in the hot air of the oven of a kitchen-range, and carefully weighed. The flask is then placed on the frame of a gas-furnace, and the water evaporated until the fluid is reduced to the consistence of syrup. It is next removed from the frame, and thoroughly dried by means of the hot, dry air of the oven. The flask, when reduced to the same temperature as before, is now again weighed. The difference in the weights before and after the evaporation gives the quantity of residue. One millegram of this residue is equivalent to one grain per gallon of the water.

If 100 c.c. be the quantity of water evaporated, 0·1 ($\frac{1}{10}$) milligramme of residue is equivalent to one part of soluble matter in one million parts of water.

The natural quantity of solid residue in ordinary potable waters varies, in this country, from 1 grain to 20 grains per gallon.

Natural Springs are often, to a great extent, impregnated with soluable substances, derived from the rocks they percolate; whilst river and well waters are almost invariably contaminated, to a greater or less extent, with soluable matters, saline and organic. In limestone districts carbonate of lime and magnesia, dissolved in excess of carbonic acid, which all natural waters contain, is usually held in solution, and is one of the most common impurities of spring water. The peculiur property it acquires by the presence of these salts of lime and magnesia is termed hardness. If it be a carbonate, it is called *temporary*, because, on boiling, the excess of carbonic acid is driven off, and the carbonate, being insoluble, may be nearly removed by filtration. It may also be removed by mixing the hard water with lime water, when both the natural water and the lime water precipitate their soluble lime as carbonate. Upon this principle Clark's process of rendering hard water soft is based. A supply of hard water to cities and towns is, in many respects, a source of loss and inconvenience, in the consumption of soap in particular, and boilers speedily become injured by being lined with a deposit of stony incrustation. This process of softening is now become one of considerable importance, and is in practice by the water companies of London for effecting this object. The hardness of water manifests itself by its peculiar behaviour with soap. Hard waters produce a lather when agitated with soap only after all the lime and magnesia have separated from the solution in the form of an insoluble lime or magnesia fatty acid salt, or soap. Clark's soap-test, for ascertaining the *degrees* of hardness of water, is based upon these facts.

Dr. NOAD, in his valuable Manual on Chemical Analysis, gives an account of this soap-test, which we beg leave to here quote: —"We are indebted to Dr. Clark for a very simple method of determining the *degree* of hardness of a water. It consists in ascertaining the quantity of a standard solution of soap in spirit required to produce a permanent lather with a given quantity of water, under examination, the result being expressed in degrees of hardness, each of which corresponds to 1 grain of carbonate of lime in a gallon (70,000 grains of distilled water) of the water. From the specification of his patent (enrolled 8th September, 1841) we gather the following particulars :—

Sixteen grains of pure Iceland spar (carbonate of lime) are dissolved (taking care to avoid loss) in pure hydrochloric acid; the solution is evaporated to dryness in an air-bath, the residue is again re-disolved in water and again evaporated; and these operations are repeated until the solution gives to test-paper neither an acid nor an alkaline reaction. The solution is made up by additional distilled water to the bulk of precisely one gallon. It is then called "the standard solution of 16 degrees of hardness." Good London curd soap is dissolved in proof spirit, in the proportion of one ounce of avoirdupois for every gallon of spirit, and the solution is filtered into a well-stoppered phial, capable of holding 2,000 grains of distilled water;

100 test measures, each measure equal to 10 water-grain measures of the standard solution of 16 degs. of hardness, are introduced. Into the water in this phial the soap solution is gradully poured from a graduated burette; the mixture being well shaken after each addition of the solution, until a lather is formed of sufficient consistence to remain for five minutes all over the surface of the water, when the phial is placed on its side. The number of measures of soap solution is noticed, and the strength of the solution is altered, if necessary, by a further addition of either soap or spirit, until exactly 32 measures of the liquid are required for 100 measures of the water of 16 degrees of hardness. The experiment is made a second and a third time, in order to leave no doubt as to the strength of the soap solution, and then a large quantity of the test may be prepared; for which purpose Dr. Clark recommends to scrape off the soap into shavings, by a straight sharp edge of glass, and to dissolve it by heat in part of the proof spirit, mixing the solution thus formed with the rest of the proof spirit.

The process for ascertaining the hardness of water.—Previous to applying the soap test, it is necessary to expel from the water the excess of carbonic acid—that is, the excess over and above what is necessary to form alkaline or earthy bicarbonates, this excess having the property of slowly decomposing a lather once formed. For this purpose, before measuring out the water for trial, it should be shaken briskly in a stoppered glass bottle half filled with it, sucking out the air from the bottle at intervals by means of a glass tube, so as to change the atmosphere in the bottle; 100 measures of the water are then introduced into the stoppered phial, and treated with the soap test, the carbonic acid eliminated being sucked out from time to time from the upper part of the bottle. The hardness of the water is then inferred directly from the number of measures of soap solution employed, by reference to the subjoined table. In trials of waters above 16 degrees of hardness, 100 measures of distilled water should be added, and 60 measures of the soap test dropped into the mixture, provided a lather is not formed previously. If, at 60 test measures of soap test, or at any number of such measures between 32 and 60, the proper lather be produced, then a final trial may be made in the following manner:—100 test measures of the water under trial are mixed with 100 measures of distilled water, well agitated, and the carbonic acid sucked out; to this mixture soap test is added until the lather is produced, the number of test measures required is divided by 2, and the double of such degree will be the hardness of the water. For example, suppose half the soap test that has been required correspond to $10\frac{5}{10}$ degrees of hardness, then the hardness of the water under trial will be 21. Suppose, however, that 60 measures of the soap test have failed to produce a lather, then another 100 measures of distilled water are added, and the preliminary trial made, until 90 test measures of soap solution have been added. Should a lather now be produced, a final trial is made by adding to 100 test measures of the water to be tried 200 test measures of distilled water, and the quantity of soap test required is divided by 3; and the degree of hardness corresponding with the third being ascertained by comparison with the standard solutions, this degree multiplied by 3 will be the hardness of the water. Thus, suppose 84·5 measures of soap solution were required

$\frac{84{\cdot}5}{3}$ = 28·5, and on referring to the table this number is found to correspond to 14°, which multiplied by 3, gives 42° for the actual hardness of the water."

Table of soap test measures corresponding to 100 test measures of each standard solution:—

Degree of Hardness.	Soap Test Measures.	Degree of Hardness.	Soap Test Measures.
0	1·4	9	19·4
1	3·2	10	21·3
2	5·4	11	23·1
3	7·6	12	24·9
4	9·6	13	26·7
5	11·4	14	28·5
6	13·6	15	30·3
7	15·6	16	32·0
8	17·5		

This scale (Dr. Clark's) is constructed to ascertain the quantity in grains of carbonate of lime or its equivalents of alkaline or earthy salts that may be contained in a gallon of water. Wanklyn and Chapman propose a scale to adjust the want of correspondence in the terms of the degree of hardness and the measures of soap test. In place of making 16 (or 32) measures of soap test to correspond to 16 grains of carbonate of lime or its equivalent in one gallon of water, they make the measure 17 (or 34) of soap test, and the correction may be said to harmonize the table. They also suggest, as being more accurate and convenient, the adoption as a standard a solution of chloride of calcium, each cub. cent. of which to contain chloride of calcium equivalent to 1 milligramme of carbonate of lime. It is prepared thus:—"Good chloride of calcium, which is prepared by dissolving a little marble in pure hydrochloric acid, is fused in a platinum crucible, which has been previously cleansed, ignited, and weighed. From 0·1 to 0·2 grm. of the chloride is taken. After heating the chloride of calcium so as to fuse it, the lid is put on to the crucible, and the whole cooled and weighed. The difference between the weight of the empty crucible and the weight of the crucible containing the chloride of calcium, which has been fused, will be the weight of the chloride of calcium employed. Dissolve it in a little water, and, calculating from the known weight, make up with water so as to get a solution of which one litre contains 1·110 grmme. of chloride of calcium."

The Standard Soap Test to correspond is made in the following manner:—"Take two parts of lead plaister and one of carbonate of potash, pound them well together, and exhaust repeatedly with alcohol of about 90 per cent., using altogether about 30 times as much alcohol as lead plaister. It will be found convenient to pound only small quantities of lead plaister and carbonate of potash at one operation. The soap solution obtained, as first described, is a solution of potash-soap, carbonate of lead being the complimentary product. Before being used, the soap solution should be allowed to stand for some time and then filtered. Before being standardised, it should be diluted with its own volume of water, and will then be still far too strong for use." To effect this—"Measure accurately say 10 c.c. of the unstandardised soap solution, put it into a bottle with 70 c.c. of pure water, and then add the standard chloride of calcium solution (strength, 1 c.c. = 1 milligramme carbonate of lime) until frothing stops, care being taken to shake up properly. From the result of the trial calculate how much dilution of the soap solution is requisite in order to make 17 c.c. of the soap test consume 16 c.c. of the cloride of calcium solution; dilute the unstandardised soap solution accordingly with alcohol of 40 per cent., and verify the standardised soap test after it has been made up.

"17 c.c. of standard soap test should accurately neutralise 16 c.c. of standard chloride of calcium solution in the presence of 70 c.c of pure water; and each c.c. of the standard soap solution will then be equivalent to 1 milligramme of carbonate of lime."

The process for ascertaining the hardness of water by this scheme has much to recommend it, as tending to establish a system of standards in conformity with the decimal arrangements, thus affording a facility for calculation of the minute quantities met with in water analysis.

The way of taking the degree of hardness is thus laid down:—"Take 70 c.c. of the water and put it into a proper bottle. Add the standard soap-test until lather is formed, and note down the number of c.c. of standard soap-test required. Each c.c. of standard soap consumed indicates 1 grain of carbonate of lime, or its equivalent in one gallon of water." If the quantity taken be 100 c.c.

of the water, each c.c. of the standard soap solution, used until a lather is produced, will be equal to 10 milligrm. of carbonate of lime, or its equivalent in one litre of water. These decimal degrees can readily be converted into Clark's grains per gallon by multiplying by 7, and removing the decimal point one place to the left, thus:—Some London water contains 23·1 degrees of hardness in 100,000 parts of water—then 23·1 + 7=16·17.

The saline and other impurities found in potable water consist chiefly of carbonic acid in combination with lime and magnesia, minute proportions of hydrochloric, nitric, and nitrous acids; soda, sulphate of lime, silica, alumina, sand, clay, and traces of the heavy metals, are also sometimes discovered. However, the small quantity of earthy and other salts which these waters usually contain does not always impart to them qualities rendering them unfit as diluents. Although, should the proportion of mineral acids be considerable, it is held that some reason exists to apprehend that deleterious effects might arise. But it has been, mayhap justly, doubted whether the unhealthy condition of localities whose water supply contains these should not rather be attributed to "organic matter," so often found to exist in the potable water of most densely populated towns.

In narrating the several tests and mode of procedure adopted in the extended analysis of water, I shall be as brief as perspicuity will admit, and shall limit myself to suggesting the readiest and simplest method, as well as the most reliable re-agents used in ascertaining the presence of deleterious impregnations.

When the heavy metals are present in potable water the quantities are generally very minute, and it therefore will in every case be desirable to concentrate *to one-tenth*, in order that the metallic compound may the more readily be detected in the residue of the water thus boiled down.

Of course, in the examination of potable water, taste, odour, and colour, are points of some importance; and as these frequently seem to depend on the germination of "organic matter," the presence of certain compounds of iron, and of ingredients affording evidence of sewage, the microscope may aid in the detection.

Carbonic Acid exists in the atmosphere. It supplies carbon to plants, which by the aid of their green leaves and chemical action of light decompose the acid—carbon is absorbed and the oxygen is expelled. Carbonic acid gas is sometimes emitted in large quantities from the earth in volcanic countries. It is constantly generated whenever organic matters are actually undergoing fermentation or fermentive decomposition, and hence it is found to largely accumulate in wells, cellars, sewers, and such like places. It is freely liberated in respiration and combustion, as well as in fermentation; in the calcination of limestone it is also evolved, and it is diffused, sometimes in great abundance, in coal mines, where it obtains the name of choke-damp. The slow evaporation of water charged with the gas, whilst trickling over the sides of deep excavations, likewise assists in diffusing it through the air of the place. It has been further observed that damp sawdust or straw slowly absorbs oxygen from a confined atmosphere, and sets free carbonic acid. This gas is colourless. Its specific gravity is 1·524. Even when greatly diluted with atmospheric air, it cannot be inhaled with impunity for any length of time—it acts as a narcotic poison. It extinguishes flame even when diluted with three times its volume of atmospheric air. It is distinguished from nitrogen gas, which is also incapable of supporting combustion, by it being quickly absorbed by lime-water, which is thus rendered turbid and milky from the production of insoluble carbonate of lime, and may be rendered again transparent on continuing the agitation of the lime water in an atmosphere of the gas until the soluble bicarbonate shall be formed. This is the characteristic of carbonic acid. It may be readily obtained by introducing into a flask fitted with a bent tube water containing carbonic acid, and, applying heat, the gas can be collected over water, or equally conveniently by displacement.

Since almost all natural waters hold in solution carbonic acid, we find that lime, as soluble bicarbonate, is of very common occurrence. In lime-stone districts, spring and river water invariably contain, sometimes to a great extent, lime thus dissolved. Water thus constituted is called *temporary hard*, as it may be lessened very considerably by boiling, and may be almost entirely removed by adding to the hard natural water some lime water. The lime in this last water abstracts from the natural water the excess of carbonic acid which holds in solution the lime as a bicarbonate, and thus renders the lime in both waters a mere insoluble carbonate of lime, which may be removed by the filter. This is the principle upon which Professor Clark's patent process for purifying and softening water is based.

As previously remarked, the supply to large cities and towns of hard water is generally found to be a source of considerable inconvenience, and for the purposes of washing is attended with a very great loss of soap. But the thick stony incrustation which lines the boilers in which such water is heated, is readily removed or prevented by adding to the water in the boiler a small quantity of hydrochlorate of ammonia (sal-ammoniac). Carbonate of ammonia is thus formed, which is volatilized and passes away with the steam, and chloride of calcium remains in solution. The same process is applicable in permanently hard waters.

Lime is precipitated in its most dilute solution by dropping into the water in a test tube some solution of oxalate of ammonia, when a white precipitate is instantly produced, which is insoluble in acetic or hydrochloric acids. This test is exceedingly characteristic.

MAGNESIA is recognised by a white gelatinous precipitate, being produced on the addition of solution of caustic soda, potassa, or ammonia, which precipitate is insoluble in excess of the alkali, but soluble in solution of hydrochlorate of ammonia. A white crystalline precipitate is caused on the addition of some solution of phosphate of soda and ammonia—*immediately*, if the solutions are concentrated; after *some short time*, if very dilute, in which case stirring promotes the precipitation.

ALUMINA.—This substance is not to be confounded with clay, all of which are silicates of that base. When clays contain an admixture of carbonate of lime, they are called MARLS, and, of course, effervesce with acids. When in solution, alumina is distinguished by a white gelatinous precipitate on the addition of caustic potassa or soda, which precipitate is *soluble in excess* of the alkali. Ammonia causes a similar precipitate, which is *insoluble* in excess of the ammonia. The carbonates of potassa, soda, and ammonia, produce with the escape of carbonic acid the like insoluble precipitation.

Silicates of Alumina enter largely into the composition of a great many of the crystallised mineral substances of nature, such as felspar, granite, porphyry, trachite, and other unstratified rocks. Under peculiar circumstances (in our present state of knowledge not well understood), these rocks suffer complete decomposition, becoming changed into a soft, friable mass of earthy substance, which, if the rock contain oxide of iron, is coloured; this is the origin of clay, and from this source are silica, alumina, and other salts, derived.

Silica, a combination of silicium and oxygen, is in reality a very powerful acid; its insolubility under ordinary circumstances renders the manifestation of acid properties difficult, but when heated with fusible bases it forms salts, some of which are soluble in water, as silicates of soda, potassa, &c. Silica enters largely into the composition of many of the ancient rocks and mineral masses of which the surface of our globe is composed.

Colourless transparent rock—crystal—may be considered silica in a very pure state; flint, common quartz, agate, &c., are also chiefly constituted of this substance. As above remarked, it is not soluble in pure water, but in strong alkaline solutions it freely dissolves, and in this state have we it here to treat of. Let the powder obtained after the evaporation of any given quantity of water be mixed with three times its weight of dry carbonate of soda, and this mixture is to be fused in a small platinum crucible. When cold let the substance thus procured be boiled in distilled water and filtered; to the filtered liquor an excess of hydrochloric acid is added and evaporated to complete dryness. If silica be present, upon the addition of the acid a gelatinous precipitate is thrown down, and from this dry saline mass, by washing away with acidulated water the alkaline salts, lime, alumina, protoxide of iron, and such other bodies as may be present, silica is obtained. It is a very fine white tasteless powder, insoluble in water or in dilute acids, with the exception of dilute hydrofluoric acid. It is freely soluble in strong solutions of the alkalies.

Soda and its Salts are very soluble, and hence their detection by precipitation is not easily obtainable; their presence, however, may often be confidently determined by negative properties. Soda and its salts impart to the outer flame of the blowpipe a characteristic yellow colour.

Potassa and its Salts are all more or less soluble. A solution of tartaric acid added to a strong solution of potassa salts produces a white precipitate—cream of tartar. Agitation promotes the precipitation, as does also the addition of some alcohol. A solution of bi-chloride of platinum gives a yellow crystalline precipitate; a little hydrochloric acid or alcohol increases the delicacy and certainty of this test. Potassa and its salts impart to the outer flame of the blowpipe a purple or violet colour, which is more clearly definite if these be free from impurities.

Sulphuric Acid.—There are seven compounds of sulphur and oxygen known, viz.:

Sulphuric Acid	$s.\ o._{3}$
Sulphurous Acid	$s.\ o._{2}$
Hyposulphuric Acid	$s._{2}\ o._{5}$
Hyposulphurous Acid	$s._{2}\ o._{2}$
Sulphuretted Hyposulphuric Acid	$s._{3}\ o._{5}$

Bi-Sulphuretted Hyposulphuric Acid...	$\mathrm{S.}_4\ \mathrm{O.}_5$
Tri-Sulphuretted Hyposulphuric Acid...	$\mathrm{S.}_5\ \mathrm{O.}_5$

Cold water dissolves about thirty times its volume of sulphurous acid. If to this solution oxygen has access, the sulphurous is gradually changed into sulphuric acid, which has a most energetic attraction for water. In all soluble forms of combination, this acid can easily be detected. If, on the addition of some solution of nitrate of baryta or of chloride of barium, a white precipitate, insoluble in nitric acid, is produced, sulphuric acid is indicated.

Nitric and Nitrous Acid.—There are five distinct compounds of nitrogen and oxygen known:—

Nitrous Oxide	$\mathrm{N.\ O.}$
Nitric Oxide......................	$\mathrm{N.\ O.}_2$
Nitrous Acid	$\mathrm{N.\ O.}_3$
Hyponitric Acid	$\mathrm{N.\ O.}_4$
Nitric Acid	$\mathrm{N.\ O.}_5$

These acids form with bases an extensive and very important group of salts, which are all soluble in water. We know of no precipitant reliable for their detection in that state. A solution of indigo in *pure* sulphuric acid, when boiled with nitric acid, becomes free from colour. This test is satisfactory only where care is taken that no chlorine be present, because of the well-known bleaching property—chemical action—of this latter substance.

Nitric acid and hyponitric acid are decomposed by water—binoxide of nitrogen, or nitric oxide, and nitric acid, being the result. It may be also well to remember that the deep-red fuming acid, called in commerce *nitrous* acid, is really nitric acid impregnated with hyponitric acid gas.

The presence of nitrogen in an organic compound is readily ascertained by mixing a quantity with some solid caustic potassa, placing the mixture in a test-tube, and applying heat. If nitrogen be present it is converted into ammonia, which is recognised by its pungent odour and alkaline reaction, and by the Nessler test.

There are several processes in use for detecting the presence of nitrates or nitrites. There is first, Pugh's plan, which consists in converting nitric acid into ammonia by protochloride of tin, by means of sealed tubes at high temperatures; there is Harcourt's plan of reduction with iron and zinc; Pelouze's, with a protosalt of iron; there is Frankland and Armstrong's plan which is a modification of Crums', and is published in detail in the *Journal of the Chemical Society* for March, 1868; and there is, also, recently described in the same *Journal* a modification of Schulze's plan. This process, perhaps, recommends itself by the facility with which it can be conducted. It consists of acting upon the nitrates and nitrites with metallic aluminium in the cold and in strongly alkaline solution, by means of which ammonia is formed. I shall give the process in detail:—

Introduce into a retort one hundred cubic centimetres of the water holding in solution nitrates or nitrites, and add seventy cubic cent. of a solution of caustic soda (composed of 100 gram. to 1 litre of distilled water). The contents of the retort is distilled until about one-third passes over, or so long as ammonia is disengaged—(this may be ascertained by the Nessler test*) When the retort is now cooled, a piece of thin sheet aluminium is put into it, and the mouth of the retort is closed with a cork, through which passes the narrow end of a small tube filled with pieces of broken-up tobacco-pipe,

* See page

wet with very dilute hydrochloric acid, free from ammonia. To this tube (which may be two inches long and not larger than a goose quill) a second tube, containing some pieces of pumice stone moistened with strong sulphuric acid, is connected. This second tube is to prevent any ammonia from the atmosphere entering the retort. The apparatus thus arranged is allowed to so remain for some hours, that the aluminium may convert the nitrites and nitrates into ammonia. In order to ascertain if this be effected, wash with distilled water the contents of the first tube, and add it to that in the retort; this is adapted to a condenser, through which a little pure water has just been distilled to insure its perfect cleanliness and freedom from all traces of ammonia. The liquid in the retort is next distilled, until about one-half passes into the condenser, and the distillate is increased to 150 cub. cent. by the addition of pure distilled water; the Nessler test is now applied.

Messrs. Wanklyn and Chapman in their excellent little book, recently published, proposes the following process :—

"Prepare a soda ley by dissolving 100

grm. of solid soda in water and diluting to a litre, and insure its freedom from nitrates by taking the soda as free from them as can be obtained in the first instance, and subsequently dissolving a very little aluminium in the cold solution of the alkali. Take 200 c.c. of this soda ley, and mix it with 200 c.c. of the sample water, and place in the mixture a bit of metallic aluminium. Allow the aluminium to dissolve in the cold, and the liquid to become clear. There will thus be got a liquid containing the original ammonia, and the ammonia arising from the nitrates. Every 100 c.c. of this liquid will contain 50 c.c. of the sample of water.

For comparison liquid, take 200 c.c. of the soda ley and dissolve in it, in the cold, the same quantity of aluminium as before. When the aluminium has dissolved, add 200 c.c. of the sample water, and allow to subside. Every 100 c.c. of the mixture will contain 50 c.c. of the water and 50 of the soda ley. This *comparison-liquid* will be like the first one in every respect, except one: whereas the first one has the nitrate reduced to ammonia, this comparison liquid will have the nitrates in the unreduced state. Decant and determine the ammonia by the "NESSLER TEST,".(using the comparison liquid instead of distilled water, and using the standard ammonia of strength 0·1 milligrm. per 1 c.c.)

In order to accomplish this, pour into separate glass cylinders an equal quantity, say 50 cub. cent. of the sample water in which the soda ley and aluminium is dissolved, and 50 c.c. of the "comparison liquid." Add to the solution containing the water for analysis NESSLER's re-agent drop by drop from a pipette, holding 1 cub. cent., until a colour is produced, observing carefully and marking the quantity required to effect the colour.

To the comparison liquid, the same quantity of "NESSLER's re-agent," as was used in the sample water, is to be added, and next carefully drop from a graduated burette so much of the standard solution of ammonia ($\frac{1}{100}$ of a millgr. sulphate of ammonia to 1 c.c. of distilled water) as shall be necessary to produce a colour corresponding with that caused in the sample water. Allow the vessels to rest for some minutes. If the colouration is now equal in both liquids, the amount of standard solution of ammonia used will represent the quantity of ammonia in the water under examination. If not, the experiment must be made by first adding a different amount of standard solution of ammonia, and then the NESSLER'S TEST.

In this reduction process the acid is decomposed, a portion of its oxygen combines with the metal, and the nitrogen thus freed unites with the hydrogen to form ammonia, whilst the carbon in the solution converted into carbonic acid is retained by the alkali. It is, therefore, evident that the proportion of nitrogen in the ammonia is the measure of the nitric and nitrous acids present in the water under analysis.

It will be observed that the *comparison-liquid* contains as much *original ammonia* as the liquid which is to be compared with it, and that, therefore, no correction is needed for original ammonia. Before mixing the sample of water with the soda ley—whether to make the liquid to be reduced or the *comparison-liquid*—add a very little chloride of calcium, so as to get an appreciable quantity of precipitate on mixing with the soda ley.

It will be understood that when the ammonia originally present in water is large relatively to that given by the nitrates—as occasionally happens—this plan without distillation would not be advantageous.

It is, of course, open to the analyst to expel the free ammonia more or less completely by boiling the water before commencing the operation of determining the nitrates."

When animal and vegetable organic compounds undergo the process of decomposition some nitrogen and oxygen unite to form nitric acid; nitrogen and hydrogen to form ammonia; sulphur and oxygen to form sulphuric acid; sulphur and hydrogen to form sulphide of hydrogen—sulphuretted hydrogen—and other compounds are formed. The presence, therefore, of these substances, or their salts, in water is regarded as indicating its defilement, possibly from sewage contamination, which had undergone fermentation, putrefaction, or destructive decomposition; and it is assumed that at the precise periods when these processes are in the acme of progression, such water as a diluent is then exceedingly dangerous.

Chlorine.—It is hardly possible for water to be defiled with sewage without being abnormally loaded with chlorides; and as traces of these are often found in naturally pure water, it is of some importance to be able to determine the amount contained in any given quantity of potable water.

In estimating the quantity of chlorine contained in water, the following is given to illustrate the plan generally heretofore adopted. An ascertained quantity of the water is mixed with fused and powdered chromate of lead; this is enclosed in a small glass bulb with a narrow stem, and is then placed in a combustion-tube of greater length than ordinary. The combustion-tube is now nearly filled with fragments of pure quicklime. The tube is next heated in a gas-stove until the lime is rendered incandescent. The vapour is thus driven over the heated lime, which, parting with its oxygen, becomes calcium, whilst the chlorine in the vapour combines with the calcium thus produced, and forms chloride of calcium. When cold, the contents of the tube are dissolved in dilute nitric acid and filtered.

The chlorine is ascertained by dropping into some of this fluid placed in a test-tube a standard solution of nitrate of silver, when a white curdy precipitate, insoluble in nitric acid, is produced; this precipitate is freely soluble in ammonia, and is apt to blacken on much exposure to light.

The quantity of chlorine in potable water is in general so very small, that to detect the minutest quantity a very delicate process has recently been introduced, and is now usually adopted. It is thus conducted:—

"70 or 100 c.c. of water are taken; a drop of a solution containing about one-half a milligram of neutral chromate of potash added, and then the standard silver solution drop by drop until a permanent red colour begins to form."

"If 70 c.c. of water have been taken, the number of cub. cent. of silver solution consumed will represent the number of *tenths of a grain* of chlorime in a gallon of water."

If 100 c.c. of water be submitted to like treatment, the number of silver solution will represent the number of parts of chlorine in one million parts of water.

Chlorine is most readily and conveniently detected by this process, which is founded upon the fact, that when to a solution containing chlorides and chromates nitrate of silver is added, it first unites with the chlorine forming the white precipitate—chloride of silver—and when all the chlorine is thus engaged, then only does the nitrate attract the chromic acid and form a chromate of silver, which is of a reddish-brown colour.

The standard solution of nitrate of silver is composed of 0·479 grms. of the nitrate in 1 litre of pure distilled water:—"One c.c. corresponds to 0·1 milligram of chlorine."

SULPHIDE OF, OR SULPHURETTED, HYDROGEN.—This gas is often a result of the decomposition of animal and vegetable organic bodies when left to putrefactive change, and is readily detected by its peculiarly offensive odour of putrid eggs. It is found in certain mineral springs — Harrowgate, and other places. Its solution in water possesses some of the properties of an acid. It reddens moistened litmus paper. The smallest trace of this gas blackens salts of lead, and hence the best test for its presence is bibulous paper wetted with a solution of acetate of lead.

IRON.—As a *per*salt of iron decomposes "organic matter," it is desirable to ascertain its existence. We know that, should this salt of iron be present in a considerable proportion to the "organic matter," the "organic matter" will not be found in solution; and that, should iron be present in the state of *proto*salt, the water may hold in solution large proportions of "organic matter." In this latter case, although quite transparent when immediately drawn from the well, it will, after having been exposed to the atmospheric air for some time, become cloudy, and ultimately deposit a flakey reddish precipitate, which is found to be constituted of basic salt of iron, retaining the whole, or nearly the whole, of the "organic matter." It appears also that "organic matter" is carried down with the carbonate of lime, and so removed from the water, by the admirable *softening process* of Dr. Clark. It is frequently observed that *traces* of iron are present in well water, owing to the iron pumps through which it is obtained; and it may be suspected if, after a short time, the water assumes a light ochery colour. It will, therefore, be necessary, in almost every case, to test for iron. If, on the addition of a little saturated solution of sulpho-cyanide of ammonium, a pink colour is produced, a *per*salt is indicated; if it be a *proto*salt of iron, a few drops of nitric acid must, in the first instance, be added to the water in the test tube, and then the sulpho-cyanide. On the addition of nitric acid the *proto*salt is converted into a *per*salt of iron, and then it is detected by the sulpho-cyanide, which shows that the iron exists in the water as a *proto*salt. When both salts are present, on the addition of a few drops of nitric acid to the water containing the *per*salt a deeper colouration results.

LEAD.—Natural water charged with carbonic acid cannot with impunity be kept in leaden cisterns, or passed through leaden pipes. When metallic lead is put into *pure* water and exposed to atmospheric air, in a few hours an hydrated protoxide is formed by the action of the oxygen contained in the water. This is a white crystalline scaly powder, and is slightly soluble. In the majority of cases, however, this substance is composed of carbonate and hydrate, due rather to the action of the carbonic acid in the pure water, and is very insoluble. Should river or well water be substituted, the minute quantity of salines almost invariably present causes a deposit of a very thin and closely adherent film—generally of sulphate of lead—upon the surface of the clean metal. By thus protecting the lead from further chemical action, the cisterns and pipes are often preserved for a considerable time for holding water ; whereas, if the water be perfectly pure, it soon becomes impregnated, and the pipes and cisterns destroyed.

This metal is readily detected by a solution of sulphuretted hydrogen, and sulphide of ammonium, either of which causes a black precipitate—sulphide of lead. Sulphuric acid causes a white precipitate—sulphate of lead, insoluble in nitric acid.

Zinc.—In consequence of the pretty general application of this metal to the construction of water-channels, and for roofing purposes, its salts may occasionally be detected in the water supply of large towns. These salts are very easily distinguished. A solution of sulphuretted hydrogen causes *no change*, whilst sulphide of ammonium throws down a white precipitate—sulphide of zinc. A solution of ferrocyanide of potassium produces, with salts of zinc, a *white* precipitate.

Copper.—In some mining districts salts

of this metal is found to exist in minute quantities in the ordinary water-supply of the locality. The characters of salts of protoxide of copper are well defined. A solution of sulphuretted hydrogen and of sulphide of ammonium cause a black precipitate—sulphide of copper. A solution of ferrocyanide of potassium produces a reddish-brown precipitate—ferrocyanide of copper. In all cases the water should be slightly acidulated, and as, generally, the quantity of metal is very minute, the water must be concentrated by boiling previously to using the tests.

Manganese and Arsenic are metals whose salts are said to be sometimes found in the ordinary water of mountainous districts. It, therefore, will be well to look for these impurities. Sulphide of ammonium gives a flesh-coloured precipitate with Manganese, and we have in a solution of peroxide of hydrogen an unerring test. When this solution is added to water which has been rendered alkaline with caustic soda, a bulky-brown precipitate is the result. If the quantity of the manganate be exceedingly minute this re-agent gives a brown colouration. We have an equally delicate and reliable test for ARSENIC in the production of arsenical hydrogen, by means of a MARSH's apparatus. From the quantity of metallic deposit, and the extent of the arsenical spot on the porcelain held over the flame of the arsenical hydrogen, an idea of the amount of this metal may be approximated.

Arsenic is sometimes found in metallic zinc; and as in cities and large towns zinc is used rather generally for water-shoots, rooffing purposes, and is applied to many domestic contrivances, arsenic in this way occasionally may find its course to the water pumps. The process with MARSH's apparatus is quite simple:—The water is poured into it, and into the short leg of the tube a piece of *pure* zinc is placed; the cork, fitted with a stop-cock and narrow jet, is replaced, and pure sulphuric acid is added through the other leg. Hydrogen is generated, and if arsenical salts be present they are reduced, and, combining with the hydrogen, form arsenical hydrogen gas. This collects and forces the water back into the upper bulb, which acts by its hydrostatic pressure, and expels the gas through the jet so soon as the stop-cock is opened. This gas is then burned, and a piece of porcelain or glass held over the flame near the point receives a dark stain from the deposit of arsenic; this stain, when the quantity is very minute, is of a clear hair-brown colour, reviewed by transmitted light. But it may be urged this is no certain evidence that arsenic is present, as antimony, when treated similarly, leaves a dark stain. This objection is removed by the circumstance that when a piece of card or paper is moistened with ammonio-nitrate of silver, and held about an inch above the point of the flame of the jet, if arsenic be present it will be found to be coloured yellow—arsenite of silver, soluble in acetic acid and ammonia. Further, a solution of nitrate of silver on paper is rendered blackish, if exposed to the unignited arsenuretted hydrogen gas. The formation of the yellow arsenite distinguishes the arsenical flame from that of any other.

Ammonia has its chief source from the putrefactive change of the weakly united and easily decomposed azotised principles of the animal and vegetable kingdoms. It is obtained from the destructive distillation of these substances. It also can be produced by the deoxidation of nitric acid, as this latter may result from the oxidation of ammonia.

Ammoniacal Salts when heated with hydrate of lime or a solution of soda or potassa evolve ammonia.

Most kinds of water contain ammonia or its salts, which either did exist as a constituent of organic matter, or, having been obtained from the atmosphere, will become presently united with other constituents to form organic matter. To devise a process specially adapted to detect and to estimate very minute quantities of ammonia in any solution, is a sure step to the final determination of the relative quantities of nitrogenous organic impurities in water.

It will not be denied that in recent times the properties and composition of the substances which constitute animal and vegetable bodies have occupied the attention and research of chemists of the highest eminence, and yet how much still remains undetermined!

The influence of solar light in promoting the formation of innumerable compounds in the vegetable kingdom—the chemical actions resulting from the food and atmospheric air necessary for the existence of animal life—a definite perception of those substances which are included under the phrase "protein principles"—where protein is the first and carbonate of ammonia is the final product of decomposition, these and many other of a like nature are questions the satisfactory solution of which must tend to the advance of medical science. However, it is an established principle that the elements of complex inorganic substances are composed of constituents united in the most powerful affinities, producing a state of considerable permanence and great durability. But this is not so in the case of an organic substance of three or four elements combined; molecular disturbance of any kind is sufficient to destroy the integrity of such an organic compound. The agency of heat for instance, by exalting the attractions, cause carbon and oxygen to unite, forming carbonic acid; hydrogen and oxygen, to form water; and nitrogen increases these internal sources of weakness, by its attraction for hydrogen to form ammonia. Thus, then, it may be assumed that those bodies which, from the number of their elements and the irregularity of the equivalent relations of their constituents, are most complex, are the least stable, and are incapable of long resisting the action of any disturbing force. Upon this law are founded some of our best re-agents—it governs the chemical actions in detecting ammonia by "NESSLER'S TEST."

Nitrogenous substances existing in water point to the source of impurity. This next demands attention. We possess an unerring test for ammonia. The experiments of Messrs. Wanklyn and Smith, in reference to the presence of nitrogenous substance in water, are entitled to much consideration. They have shown that, on distilling water containing urea *(a frequent ingredient in sewage)*, ammonia is obtained. Further, nitrogenized organic substances, when heated in a tube, usually char or blacken—owing to the separation of carbon—and evolve *alkaline* vapours having a peculiar odour, not unlike ignited horn; the alkalinity is shown when *moistened red* litimus paper becomes blue; and being volatile, indicates the alkalinity to depend upon the presence of ammonia, the result of the decomposition. If nitrogen assumes the form of nitric acid, or of a nitrate, it may sometimes be detected by adding to the water under examination in a test-tube an equal volume of concentrated sulphuric acid and a few copper filings. Apply heat, vapours are produced, which, on looking down the tube, appear of a red-brown colour—the red fumes of nitrous acid gas.

The recent researches upon limited oxidation by Frankland, Armstrong, Wanklyn, Chapman, Tichborne, and others, have shown that the results of the action of oxidisers upon "organic matter" in solution are variable, and often complicated; and therefore that the utility of permanganate of potassa as a quantitive test of "organic matter" is worthless. A mode of estimating, with facility and accuracy, the relative amount of "organic matter" in potable water therefore became desirable. The *quantity*, however, is, perhaps, of less importance than the fact of its presence; and in this sense the following processes are submitted, as being ready and reliable:—Let 20 ounces of the water to be examined be poured into a flask, and be boiled down to two ounces. When cold, three drachms of the concentrated water may be put into a test-tube, and add one drop, from a half-ounce vial, of pure diluted sulphuric acid, and, from an ounce vial, one drop of a solution of permanganate of potassa, composed of one grain of permanganate, to one drachm of distilled water. A beautiful pure violet colour is produced. The test-tube containing the fluids is now to be partially immersed in a water bath at a temperature of 120.F. for half-an-hour. Should the colour change within *ten* minutes, "organic matter" in large proportion is indicated, and may be pronounced to so exist; if the change be more gradual, first to pink and then to red or brown, "organic matter" is present in abundance; if the colour be changed to pink or red *within the half hour*, "organic matter," in considerable proportion, is indicated; if it should be but *little changed* after having been in the bath, and next day the change of colour be *well marked*, "organic matter" is present in appreciable quantity; and if the colour be decidedly, however slightly, changed, "organic matter" undoubtedly exists in the water thus examined. In applying this test we should guard against the fallacy that the deoxygenation of the permanganate might be produced by "organic matter" in the atmosphere. In ordinary cases, without incurring the expense of certain costly apparatus, this can be sufficiently accomplished by purifying, if it be necessary, in the usual way, any small apartment. If the colour be not in the least degree altered or changed after having been in the bath, and after having been subsequently kept exposed to the action of light and atmospheric air for forty-eight hours, I think we are safe in pronouncing such water, if it be otherwise unobjectionable, as potable.

HERR VON PETTENKOFER proposes as a test for the detection of nitrogenous organic substances, a saturated solution of sugar mixed with dilute sulphuric acid. This gives a rose-red hue, more or less deep, according to the quantity of organic matter present.

SCHULTZ's test serves, like the preceding, to detect the presence of nitrogenous organic matter. This is a solution of chloride of zinc, iodine, and iodide of potassium in distilled water, and is made thus:—Pure metallic zinc is dissolved in hydrochloric acid, and the solution is evaporated in contact with the metal until it attains the consistency of a syrup; this is then saturated with iodide of potassium, and iodine is lastly added.—Each of these—*Pettenkofer's* and *Schultz's* tests—will sometimes succeed where the other fails, and therefore it may be necessary in doubtful cases to employ both.

NESSLER'S test is a solution of iodide of potassium saturated with biniodide of mercury, and rendered powerfully alkaline with soda or potassa. This test, which is most delicate, has been made quantitive by MILLER, and is adopted in a modified form by *Wanklyn* and *Chapman*, from whose book we quote the mode of preparation:—"Dissolve 50 grammes of iodide of potassium in some hot distilled water. Place the vessel containing this solution in the water bath, and add to it a strong aqueous solution of bichloride of mercury, which will cause a red precipitate that disappears on shaking up the mixture. Add the solution of bichloride of mercury carefully, shaking up, as that liquid is added, so as to dissolve the precipitate as fast as it is formed. After continuing the addition of the bichloride of mercury for some time, a point will ultimately be reached at which the precipitate will cease to dissolve. When the precipitate begins to be insoluble in the liquid, stop the addition of the bichloride of mercury. Filter. Add to the filtrate 150 grammes of solid caustic soda in strong acqueous solution, or about 200 grammes of solid potassa dissolved in water. After having added the solution of alkali as just described, dilute the liquid so as to make its volume equal one litre. Add to it about 5 c.c. of a saturated aqueous solution of bichloride of mercury. Allow to subside, and decant the clear liquid, which is the NESSLER re-agent." It is used in this manner:—Pour some of the water under analysis into a flask, and place it upon the frame of a gas-stove until the water is about to boil, and thus expel its normal ammonia. When this is cold, carefully filter through paper free from traces of ammonia, and add one cubic centimetre of "NESSLER'S RE-AGENT." Should this cause a brown colouration, we may have no hesitation to pronounce its impurity; but the occurrence of a dark brown precipitate is in itself, without any further examination, a sufficient justification for unreservedly condemning as potable any such water.

As the presence of many saline and other substances will cause a precipitate with the "NESSLER'S RE-AGENT," and thus create an uncertainty of interpretation, it becomes desirable to elude this difficulty, and at the same time be enabled to detect the presence of urea as well as albuminoid matters. For this purpose the mode of procedure must be thus conducted:—Take some of the water, add solution of chloride of calcium drop by drop so long as any discolouration or precipitate appears; then a slight excess of saturated solution of soda. Filter through paper free from all traces of ammonia. Pour some of this into a retort or flask fitted with a bent glass tube and receiver, carefully cleansed. Place the retort or flask upon the frame of the gas-stove, and distil over one-half, or until the distillate passing over is free from ammonia. In this distillate are contained the normal ammonia, and ammonia the result of the decomposition of any urea that may be present.

To ascertain the certain existence of urea:—Take some of the water, add a few drops as before of a solution of chloride of calcium and solution of soda. Filter. We now have two samples of water. One the distillate containing original ammonia, and that, the result of decomposition of urea; whilst the other, the filtered sample, contains the ammonia in its normal quantity as in the original water. Both samples must now be carefully submitted to examination by means of the "NESSLER'S RE-AGENT," and the solution of standard ammonia, as will be given further on.

The difference in the amount of ammonia contained in each is equal to the ammonia obtained from urea. Now, as one hundred parts of urea evolve about seven parts of ammonia, a calculation as to quantity can be readily made, if required.

To ascertain albuminoid matters:—To the water remaining in the retort or flask, some solution of potassa and permanganate of potassa is added; and the distillation is carefully pushed until one-half passes over, or until ammonia cease to be evolved. In this distillate we have the ammonia the result of the chemical decomposition of all organic matters in which nitrogen enters as a constituent. The presence and the quantity of ammonia is determined by means of the "*Nessler's re-agent*" and the "*Standard ammonia solution*"; and as one hundred parts of albumin evolve ten parts of ammonia when thus experimented upon, it follows that the nitrogenous organic matter contained in the water is ten times the amount of the ammonia obtained on distillation with alkaline permanganate. It, therefore, can with facility be calculated what quantity of nitrogenous organic substance water holds in solution.

As previously stated, it is exceedingly difficult to obtain in the natural state, perfectly pure water. However, in the present day it is almost generally admitted that the unfitness of water as a diluent chiefly depends upon the presence of what is called "organic matter." Yet, it is by some held that a difficulty in pronouncing the potability of water exists, because, as is alleged, it depends not so much upon the quantitive as the qualititive determination of this "organic matter." It is asserted that "you may have a water rich in organic matter, yet harmless; or a water containing but a minimum of organic matter, but organic matter of such a deleterious nature that our ideas of the most virulent substance fall short of the horrible results that these invisible poisons can accomplish."

It is ascertained that the average annual rain-fall in this country is somewhere about 810 millions of gallons per acre. It is true a very great portion of this quantity is evaporated, and absorbed by the atmosphere—is decomposed, becoming food for the maintenance of vegetable and animal life; and a large portion of these millions of gallons sink below the surface to supply and replenish our springs and wells or pumps.

Ansted, in his "Geological Gossip," thus conceives its "behavour in the bowels of the earth":—

"All soils are more or less porous, few absorbing less than 5 per cent., and some as much as 40 per cent. of water. We may regard the surface of the earth, wherever there is vegetation, as a huge sponge, sucking in a large qnantity of water, and conveying it to the sub-soil and surface of the rock below. When the rock is stratified or arranged in layers, some of which allow water to percolate them more readily than others, the water will accumulate in quantities on the top of those which are least permeable, and run along them till it meets some of those crevices. Where, on the other hand, the rock is hard, but also cavernous, the water will collect in the cavities; and where the rock is naturally hard, but soluble, the water will gradually wear away hollow spaces and passages. It will, in a word, circulate among all rocks—stratified or unstratified, hard or soft—will penetrate into almost every part of even the least porous rocks—will exist sometimes in open cavities, and sometimes, under great pressure, in crevices to which the day never penetrates. Almost the whole of the rain-water that enters the earth thus penetrates the rocks below the surface. It does so to a variable, though, perhaps, nowhere to a very great depth, being conducted along through underground channels and passages, often narrow and curiously contorted, trickling down the splits and crevices of the harder rocks, or gliding along the surface of the tougher ones, where, interrupted by a belt of impermeable ground, it will accumulate;" and in all cases obeys the law of gravitation. Hence do we scarcely ever find well or pump-water in cities or large towns free from organic impurities. The presence of chlorides, nitrates, or sulphates, existing *per se* in water, may not render it unfit for domestic purposes, as the presence of these does not necessarily prove in all cases defilement by the perfect decomposition and full oxidation of "previous sewage contamination." In explanation, it is suggested that the water in its course through the various geological strata might obtain those salts, arising from "fossil sewage," which in the early geological ages was deposited as organic matter. This ingenious surmise notwithstanding, we are inclined to insist that water containing these salines to be declared safe for drinking purposes should be perfectly free from the minutest trace of nitrogenous organic matters, because we apprehend that the presence of those salts, if accompanied by these matters, would indicate that organic substances were now actually being in an active state of decomposition when the water is in its most dangerous condition. We now know why it may so happen that the water of any locality rich in organic matter might be deemed harmless at one time, and soon after the same "water containing but a minimum of organic matter, but organic matter of such a deleterious nature that our ideas of the most virulent substance fall short of the horrible results that these invisible poisons can accomplish."

Ansted calculates that "a common well of ordinary depth will drain the soil and subsoil around it, through a space having the shape of an inverted cone, the shaft of the well representing its axis, and the well's mouth the centre of its base, of one mile diameter at the surface." Hence the dangerous nature of a water supply by means of town pumps, these waters having passed through a porous soil, full of nitrogenous organic impurities, derived from excreta, from defective house drainage, imperfect sewage, the refuse of slaughter-houses, the products of graveyards, and many other such sources of pollution, as necessarily must exist in all large cities and towns; these facts point to the one inevitable conclusion—that no city or large town should be permitted to have its inhabitants supplied with potable water from wells or pumps sunk or situated in the streets, and in the very centre of its innumerable pollutions.

ALBUMINOUS PRINCIPLES.—That the fluid portion of blood and the white of egg contain albumin as their characteristic ingredient, are facts generally known, and the identification of albumin is easily effected. When, in ordinary solution, it is exposed to heat, it becomes white, opaque, and solid, and if the quantity in solution be minute boiling may be required, when it separates in light minutely-formed flocks. It is also precipitated by excess of nitric acid, but not by acetic or phosphoric acids. A very weakly alkaline solution of albumin coagulates by heat, and if previously acidulated with acetic acid precipitates a solution of bichloride of mercury. But a large quantity of akali, and very minute quantities of the mineral acids in a liquid containing albumin prevent its coagulation by heat.

Until recently the process most frequently used for the estimation of the quantity of organic matter in water was its determination by the loss on ignition of the residue of water boiled down to dryness. It is now found that this cannot be relied upon as an unerring index, because water holding in solution nitrates may contain very little, if any, "organic matter;" and as nitrates give off oxygen, and even part with some nitrogen on ignition, there must, in such cases, be some loss on ignition of the water-residue, and yet organic matter may not be present. Again, nitrogenous organic matter may be destroyed by the heat necessary to evaporate to dryness. Its presence, however, is indicated where the residue on ignition blackens, or alkaline vapour appears. In the *Journal of the Chemical Society* for March, 1868, Frankland and Armstrong propose to determine the quantity of organic matter by ascertaining the quantity of carbonic acid and nitrogen which a water-residue gives off on ignition, the nitrates and nitrites having been previously removed by boiling with sulphurous acid. This process is troublesome.

The permanganate of potash test is another method proposed for the quantitive analysis of water. In this process the consumption of oxygen is the measure of organic matter. But as different sorts of organic matter are variously affected by this re-agent, and as nitrates attract oxygen, which by this mode would be determined as organic matter, Frankland and Armstrong in the *Journal*, of the date referred to, have very forcibly put forward objections to the accuracy of the permanganate test for that object.

However, as a ready and simple test of *the presence* in water of "organic matter," the permanganate gives very constant results, and may be availed of for that purpose.

The experiments, recently published, of Wanklyn, Chapman, and Smith, go far to establish a new method of determining the quantity of nitrogenous organic matter in water. It is ascertained that many specimens of water hold in solution ammonia or its salts, which has already been a constituent of an organic body, or is about to become so. It is further demonstrated that some waters do actually contain more or less nitrogenous organic matter, which furnishes ammonia on boiling with carbonate of soda, or else on adding permanganate of potassa and boiling in presence also of an excess of alkali:—"*Free* ammonia" they call ammonia evolved on boiling with soda-ley; "*Albuminoid* ammonia" is ammonia evolved by subsequent treatment with alkaline permanganate of potash—these being facts afforded by the results of the "ammonia process" of Wanklyn, Chapman, and Smith.

The amount of ammonia obtained from the water is the measure of the organic matter it of the re-agent, a trace of ammonia, if present, will produce a yellow or brown *colouration;* if, in larger quantity, a *precipitate* is obtained:—Or, to a given quantity of the water add a few drops of a solution of chloride of calcium; next, a slight excess of potassa. Let it rest for a short time. Filter. Distil until the water comes over free from ammonia. Now, when the water in the retort becomes cold, add distilled water to it, sufficient to bring up the volume to the original quantity. This is to form the liquid to be used in the place of distilled water in making the comparative solution for the indications of the Nessler's test. Next, take half the volume, as above, of the water under analysis, and add to it solution of chloride of calcium and potassa as before. Filter. Thus we have two samples of water—one without ammonia, and the other with the ammonia contained in the water under examination; and as in all other respects, they contain the same impurities, "the NESSLER test" must be effected in a like manner by the presence of salines, &c., in applying the comparisons.

The examination of water, with a view to the detection of nitrogenous organic matters by the method so satisfactorily worked out by Wanklyn, Chapman, and Smith, named, "The *Ammonia* Method," is conducted with very great certainty and facility, in consequence of being now able to use the "NESSLER'S RE-AGENT" quantitively.

As previously remarked, the presence and amount of organic matter in potable water is the most important, perhaps the only, question of vital importance connected with its analysis. It will, therefore, be manifest that every care to avoid error must be taken in the search for the presence of ammonia. This precaution is the more to be observed when operating upon minute quantities.

In conducting the process the following articles must be at hand:—

1st—Pure distilled water, perfectly free from all traces of ammonia.

2nd—An alkaline solution of permanganate of potassa, thus made:—Two hundred grammes of solid caustic potash and eight grammes of crystallised permanganate of potassa dissolved in one litre of pure distilled water. This should be boiled, in order the more effectually to expel any free ammonia.

3rd—A saturated solution of carbonate of soda, also free from ammonia.

4th—A standard solution of ammonia—made by dissolving sulphate of ammonia in pure distilled water in proportion, so that in one cub. centim. of the solution one hundred part of a milligram of ammonia is present.

5th—The "NESSLER's re-agent," the mode of preparing which is detailed at page 50.

Having cleansed and rendered free from all traces of ammonia, by boiling some distilled water in it, a flask or retort, adjust to it a glass bent tube by means of a cork; pour into this two hundred and fifty cubic centimetres of the water to be examined, and add eight cub. cent. of the carbonate of soda solution. Place the flask or retort upon the frame of the gas-stove, and distil into a carefully cleansed receiver, kept cold in the usual way, until the distillate pass over free from ammonia. In this distillate is contained any free ammonia which may have existed in the water as such, or as urea.

Next adjust another equally cleansed receiver, having previously added to the liquid in the flask or retort twenty-five cubic centimetres of the permanganate solution, and again distill, until the distillate passing over is free from ammonia. The presence of ammonia is determined by the "NESSLER test." In every case it is desirable to, in the first process, distill over at least fifty c.c., and in the second not less than twice that quantity. Some cases will happen which require prolonged boiling, in order to effect in very bad water the complete decomposition of organic matters by the permanganate. In such cases it may be necessary to add water to the contents of the flask or retort, and too much care cannot be used in ascertaining the perfect purity of the distilled water to be added on these occasions.

Each of the two samples of distillate may now be tested for ammonia thus obtained from the water under examination.

The first specimen procured may contain the ordinary free ammonia, as well as that which is the result from the decomposition of any urea which may exist in the water. The second may contain the ammonia resulting from the decomposition of albuminoid impurities, and is named by *Wanklyn* and *Chapman* "Albuminoid ammonia."

To determine the quantitive analysis, the process is thus conducted:—

Having obtained three glass cylinders, perfectly cleansed and free from all traces of ammonia, pour into two of these twenty-five *cub. cent.* of each, respectively, of the samples of the distillates, and into the other the same quantity of pure distilled water. To each of the liquids add one *cub. cent.* of the "NESSLER'S RE-AGENT" from a pipette. If a peculiar change of colour is produced in either or both the distillates, ammonia is present. The occurence of a brown colour, or a brown precipitate, on the addition of the "NESSLER'S re-agent" is of itself a sufficient indication of the unfitness of the water to be used for drinking purposes. The comparative examination will give the quantity of ammonia contained in each distillate, and is made thus:—Add to the cylinder holding the distilled water the "NESSLER'S RE-AGENT," and drop by drop from a graduated burette, the "Standard Ammonia Solution" in quantity sufficient to cause the colour to correspond with each of the distillates, taking a note of the amount of "Standard Ammonia Solution" used for each case. When the colouration is equalized in each, the amount of "Standard Ammonia Solution" used to effect the distilled water, will represent the quantity of ammonia contained in the water under analysis. As has already been observed, the ammonia obtained in the distillate from the water in which carbonate of soda is dissolved includes the free ammonia normally existing in the water and the ammonia the result of the decomposition of any urea present. Generally it is considered unnecessary to make any deduction for the free ammonia as such from the amount the result of the urea disintegration, and the whole of the ammonia found in the first distillate is usually calculated as proceeding from urea. Nevertheless, it will, perhaps, occasionally be desirable to determine with minute accuracy the amount of free ammonia present, in order to ascertain the quantity of urea held in solution. Now that we have an unerring test for microscopic quantities of ammonia, this could with facility be accomplished, were it not that potable water frequently holds in solution many substances which interfere with the indications of the "NESSLER'S RE-AGENT." To elude this difficulty, we have only to treat the water with some solution of chloride of calcium, and potassa in slight excess, and filter. The estimations of ammonia without distillation and with distillation are now made by the comparison method as given in these pages. The difference between the amounts of ammonia indicated by the "NESSLER'S RE-AGENT" after distillation and without distillation is due to the urea or other kindred bodies which may be contained in the water under analysis.

In the *Journal of the Chemical Society* for May 1868, are published analytical experiments on very minute quantities of animal substances, all of which on being heated with alkaline permanganate evolve ammonia. It has been proved that when a solution of albumin is thus operated upon, the amount of ammonia obtained is strictly in proportion to the quantity of albumin used. A large class of nitrogenous organic substances when treated with the permanganate give off all their nitrogen as ammonia, whilst other like substances evolve a part only of their nitrogen as ammonia.

In the following list the numbers express the amount of ammonia obtained by accurately conducted experiments in 100 parts of the substances named:—

Gelatine,	12·7
Albumin,	10
Uric Acid,	7
Cascine,	8·4
Creatine,	12·6

The products of the decomposition of the foregoing, of effete matters and of animal tissues, generally may be assumed to constitute what the chemists call "organic matter;" and which, when treated as detailed in these pages, would evolve about *one-tenth* of its weight of ammonia. Upon this data the disintegrating animal and vegetable refuse in river and other water is calculated to be *ten times* the quantity of the ammonia indicated by the "NESSLER'S RE-AGENT."—Wanklyn and Chapman.

The facts known in reference to the source of natural waters often render more explicit the import of the ammonia which they furnish. For instance, we perceive that river water, which having in its course passed a city or a large town, derives the greater part of its "organic matter" from sewage—from animal and vegetable substances in a state of decay.

It is surmised that most of the animal matters which have as yet escaped full decomposition and furnish ammonia when heated with the alkaline permanganate, is either albumin or some substance closely allied to it. Hence, as it is found that one hundred parts of albumin evolve *ten* parts of "albuminoid ammonia," it follows that the quantity of "organic matter" contained in the fluid must be *ten times* the amount of the ammonia. indicated. Upon these facts is the theory of the new method of determining nitrogenous organic substances founded. Its adaptation to detect and estimate microscopic quantities, specially recommend this process when analytically calculating the organic impurities dissolved in water. The "NESSLER'S RE-AGENT" enables us to demonstrate the one hundred part of a milligram of ammonia in two litres of water, equal to one part of ammonia in two hundred million parts of water! PARKES, in his *Practical Hygiene*, says that "organic matter should not exceed 1·5 gr. per gallon, and from 3·10 grains render the water unfit for human use." This then may be taken as the result given by waters of unquestionably bad character, and may provide the water-analyst with the chemical characteristics of foulness.

In the *Journal of the Chemical Society* for May, 1868, is detailed an extended series of experiments made on minute quantities of nitrogenous organic substances with alkaline permanganate, which shew that some substances evolve all their nitrogen as ammonia, and other substances evolve only a portion of it as ammonia. Articles composed of albuminous and animal tissues, generally in a state of disintegration, may be held to form the materials, the presence of which in water causes its pollution. Now it is ascertained that the quantity of ammonia obtained by distillation with the alkaline permanganate from the following substances is as expressed by the numbers, thus :—

100 parts of Albumin = 10 of ammonia
100 parts of Gelatine = 12·7 " "
100 parts of Creatine = 12·6 " "
100 parts of Hippuric Acid = 9·5 " "
100 parts of Uric Acid = 7· " "

The average we may assume as 10, and

hence the products of the chemical decomposition of a solution of these in water would evolve about $\frac{1}{10}$ of its weight of "albuminoid ammonia." Upon this data, Wanklyn and Chapman hold that "the disintegrating animal refuse in water would be pretty fairly measured by ten times the albuminoid ammonia which it yields."

ILLUSTRATIVE CALCULATIONS.—In pursuing the quantitive analysis, in accordance with the plan laid down in these pages, it will, of course, be necessary to operate upon and with proportional quantities. It will, therefore, be useful here to give the standard solutions, the interpretations upon known volumes, and the mode of estimating by calculation.

1st—*The Standard Solution of Nitrate of Silver.*—0·479 grms. in 1 litre of distilled water—1 c.c. = 0·1 milligrm. of chlorine. If 70 c.c. of water be the quantity, the volume of silver solution used will represent the number of tenths of a grain of chlorine in a gallon.

2nd—*Standard Solution of Chloride of Calcium.*—1·110 grmme. in 1 litre of distilled water—1 c.c. = 1 milligrm. of carbonate of lime. If 70 c.c. of water be the quantity tested with

3rd—*Standard Soap Solution* of a strength that 17 *c.c. will accurately consume* 16 *c.c. of the standard chloride of calcium solution*—this then will = 1 milligrm. of carbonate of lime, —and each c.c. of *Standard Soap Solution* neutralised or required to stop a lather or frothing, on agitation, indicates 1 grain of carbonate of lime, or its equivalent in one gallon of the water.

4th—*Standard Solution of Ammonia.*—·01 ($\frac{1}{100}$ part) of a milligrm. of sulphate of ammonia dissolved in one cubic centimetre of distilled water. If 70 c.c. of water be taken, and the Nessler's re-agent added, the number of c.c. of this solution required to equalize the colouration on comparison with a mixture of known quantities of distilled water, Nessler's re-agent and standard ammonia, will represent the number of hundreds of a grain of ammonia in a gallon of water; and the quantity of nitrogenous organic matter is ten times the amount of ammonia indicated.

1st Example—River water, exposed to the reception of all the various organic impurities of a large town, was procured from the river, mid-stream, below the town after heavy rain, and was submitted for analysis :—

	Milligrm. per litre.
Ammonia obtained by distillation with carbonate of soda............	2·5
Ammonia obtained by distillation with alkaline permanganate ...	5·0
	7·5

To find the number of grains per gallon of nitrogenous organic matter that this 7·5 represents, is thus calculated :—

Litre = 1·7608 English pints.
Milligramme = ·0154 grains.

$\therefore \frac{8}{1\cdot7608} = 4\cdot543$ = Litres in a gallon.

$\therefore 4\cdot543 + 7\cdot5 = 34\cdot0725$ milligr. of ammonia in a gallon.

$\therefore 34\cdot0725 + \cdot0154 = \cdot5247$ grains of ammonia in a gallon.

$\therefore \cdot5247 + 10 = 5\cdot247$,

the number of grains of nitrogenous organic matter in a gallon of water; or thus :—

$$7\cdot5 + \cdot7 = \cdot525 + 10 = 5\cdot250$$

2nd Example—Well or pump-water, obtained from a pump convenient to a burial ground in the centre of the large town as before, after heavy rain :—

	Milligrm. per litre.
Ammonia obtained by distillation with carb. soda....................	4·5
Ammonia obtained by distillation with alkaline permanganate ...	3·5
	8·0

To find the number grains per gallon that this 8, the number of milligrammes per litre, represents :—

∴ 4·543 litres in a gallon
+ 8 = 36·344 milligrm. of ammonia in a gal.

∴ 36·344 + ·0154 = ·5596 grains of ammonia in a gallon.

∴ ·5596 × 10 = 5·596,

the number of grains of nitrogenous organic matter in a gallon of water; or thus :—

8·0 + ·7 = ·560 + 10 = 5·600

These figures may be considered as quantities per gallon small, but at the same time the water holding in solution those quantities of nitrogenous organic matter display with the "Nessler's re-agent" most striking and decisive colouration, and hence shew them to be unsafe for drinking purposes.

Parkes states that the quantity of organic matter should not exceed 1·5 grains per gallon. Wanklyn and Chapman hold that all potable waters should be "of such a purity as not to yield more than 0·08 ($\frac{8}{100}$ parts) of a milligrm. of albuminoid ammonia per litre of water."

Her von Pettenkofer—perhaps the highest, certainly the highest German, authority on Hygiene, and who has devoted almost his whole time to the investigation of the subject—holds that wherever a porous soil is impregnated with human excreta, if the subsoil be watery or springy, a miasm-producing condition exists whenever hot dry weather and rainy weather succeed each other. Under these circumstances microscopic organisms are generated—the result of organic disintegration—the atmosphere, and very soon the waters in the locality become infected, thus securing the impregnation of the system, of those dwelling in the district, and using for drinking purposes those waters. In this way is explained the diffusion and great fatality attendant on any epidemic whenever the wells or pumps of the infected locality are contaminated. The application of the microscope, and of chemical re-agents to microscopic objects, have greatly aided enquiries in this direction. In the lowest and simplest forms of vegetable and animal life it is ascertained that their respective cells or vesicles are comparable in most parts of their structure, and are often transparent and not readily discernable. Those of the animal differ from the vegetable in the entire abscence of the "cellulose-wall;" they both contain albumin.

PETTENKOFER's test detects cellulose. The action of dilute sulphuric acid upon cellulose that has been previously coloured brown with a little solution of iodine under the microscope, gives it a blue or purple hue; and this, with other means at our disposal (Schultz's test), enable us to distinguish whether the infecting particles belong to the animal or vegetable kingdom.

Now we apprehend that it can scarcely be questioned that a water-supply procured by means of wells or pumps placed in the streets of large towns, and, consequently, in the centre of all this pollution, is—always more or less—sometimes dangerously charged with organic impurities; and possibly, though the quantity may be microscopical, its quality might be of the most deleterious kind.

The legitimate inference deducible from these facts is that, town wells or pumps are generally the most objectionable sources for a water supply; and apart altogether from the presence or the amount of the nitrogenous organic matter which these waters may occasionally contain, in a sanitary point of view their situation and their source are of of importance, as well as their chemical purity.

It is universally held to be indisputable that vital action implies disintegration of nitrogenized organic compounds in a state of change; and that this effete matter combines in the system with oxygen to fit it for being eliminated in part by the respiratory process, as well as by the excretory organs generally. Now, if from any cause this disintegration take place in a greater ratio than the constituents being decomposed can be oxidised and eliminated, a proportion of this "organic matter" must, of course, remain in the circulating fluids; and its accumulation causing depraved function may afford the greatest facility to the development in the system of any disease or epidemic, whatever the nature of that specific influence might be. The experiments of Smith, Liebig, and others, have amply shown that the vapour exhaled from the lungs contains a considerable quantity of "organic matter." It is also assumed, from the fact that garments long worn emit a foul odour, as well as from more expert examination, that the perspiration contains a similar substance. Hence, imperfect ventilation and overcrowding exert their deleterious effects, not alone by preventing the full oxidation and elimination of the effete substances which are normally undergoing decomposition within the body, but operate to concentrate the "organic matter" that should be excreted from the lungs and skin, which of course produce the same morbid effects upon those habitually exposed to them, as if these had their origin from some remote source. It is also a well-ascertained fact that the habitual, or even occasional, ingestion of decomposing matters in food or drink, impregnates the system with deleterious compounds, deteriorates the blood, and thus renders the individual equally susceptible to the development of disease. It is a matter, then, of direct induction that this condition of the blood—*charged with decomposing organic compounds*, however induced—is the immediate cause of the *pre-disposition state*, or, in other words, of that state of the system which renders the individual *peculiarly susceptible* to contract disease. Hence it is manifest that if, even in the minutest proportion in certain cases, "organic matters" be constantly carried into the body by the water we use as drink, it must exert the like morbid effects in the system as imperfect ventilation and overcrowding, by attracting to itself that oxygen which is required to fit for elimination the effete matters which normally undergo decomposition within the body, and, by augmenting in the blood organic matter in a state of change, induce the pre-disposition condition. This is exemplified in the fact that epidemic disease is, as it were, arrested and fixed in its transit by the denizens of lanes and alleys in large towns, which are, unfortunately, too often the receptacles of filth in all its hideous varieties.

The preceding are some of the reasons which are deemed sufficiently forcible to enable us to pronounce the opinion, that water in which nitrogenous organic matter, in the minutest proportion, exists, is unfit for drinking purposes. But there are other facts of a different order equally convincing that such water ought to be unreservedly condemned, as calculated to not alone produce the pre-disposition state, but to actually *induce disease.* To those facts I may be permitted specially to apply myself.

The investigation by the microscope of the minutiæ of organic structure has opened up a domain rich in curious and instructive disclosures, and to a few of those clear and convincing discoveries I shall briefly advert.

The elements which constitute "organic matter" are the same out of which organic bodies are composed; these, every one knows, are carbon, oxygen, hydrogen, and nitrogen, the first combination of which is into what is called proximate principles—cellulose or starch, albumin, &c. Thus the structure of the vegetable and animal organism is built up. The results of recent microscopic researches have unravelled the complexities of the elementary organizations, and have furnished the surest basis for those general notions of the true nature of vital action, which the advanced state of modern science has shown to be well founded only by being equally applicable to both kingdoms.

It is ascertained that the basis of organic substance (vegetable and animal) consists of nucleated cells—that is, cells having granules within them—reproductive, distinct organisms, multiplied by fissiparous generation or sections of themselves; and there is no single character by which the animal or vegetable nature of any organism can be tested. In his work on the microscope, Dr. Carpenter suggests, "that probably the one which is most generally applicable among those lowest organisms which most closely approximate to one another is not—as formerly supposed—the presence or absence of spontaneous motion, but the dependence of the being for nutriment upon *organic compounds already formed*, which it takes (in some way or other) into the interior of its body—or its possession of the power of obtaining its own alimentary matter by absorption *from the inorganic elements* on its exterior.

The former is the characteristic of the *Animal* Kingdom, as a whole; the latter is the attribute of the *Vegetable.*" So that all animated nature may be said to be based on this origin:—The fundamental form of any organic being is a cell globule, having a new one forming within itself, by which, in due course, it is discharged or separated, and which is again followed by others in endless succession. The protophyta, desmidiaceæ, fucoid algæ in the *vegetable*, and the protozoa, amœba, actinophrys sol in the *animal*, afford an endless variety of objects, interesting not only as exhibiting the zeal and research of recent microscopic observers, but are of greater importance, as showing what the physiologist believes himself to have ascertained. The fact can be exhibited to view, that "whilst the protophyte obtains the materials of its nutrition from the air and moisture that surrounds it, and possesses the power of detaching oxygen, hydrogen, carbon, and nitrogen from the previous binary combinations, and of uniting them into ternary and quaternary organic compounds (chlorophyll, starch, albumin, &c.,) the simplest protozoon, in common with the highest members of the *Animal Kingdom*, seems utterly destitute of any such power, and is dependent for its support upon organic substances previously elaborated by other beings."

The doctrine of an organic creation by law is ably advocated by scientific minds of the highest order—men of eminence and worth; whilst on the other side are men of at least equal ability and repute, who sustain the view that all created beings proceed from their likes, or a primordial egg. Thus, then, are two suppositions presented to us. First, that, for example, in a solution in which "organic matter" exists, *Infusoria* are called into existence by the requisite combination of atoms which the creative laws demand—light, caloric, and atmospheric air being also required. Second, that generation takes place from germs or ova existing in the water, or floating in the atmosphere, and take on action whenever they are conveyed to, or light upon, their *proper element.*

There are several eminent in science who frankly profess to find at least great difficulties in accepting the doctrine of invariable oviperous generation, and who view the nature and mutual relations of those subtle and all-pervading agencies — call them cosmic forces, imponderable elements, or whatever other name best expresses the little we really know about them—which present themselves to our senses in the phenomena of light, caloric, electricity, magnetism, and, perhaps, vegetable and animal life, as showing that they are possibly phases of only one and the same principle, modifications of some expansive primeval force or activity, or property of ethereal matter, universal as gravitation, and, mayhap, antagonistic thereto.

In the *British and Foreign Medical Review* the doctrine of organic creation by law is thus advanced:—"We see a simple germ, the nucleus of a cell, develop itself into a feeling, thinking man, by drawing into itself, and combining into new forms, the particles of what we are accustomed to call inorganic matter. These new forms are caused by the very act of combination to manifest properties of a new and peculiar kind, and their actions constitute the life of the being. Hence we must attribute to all those substances, which are thus drawn from the inorganic into the organic mode of existence, a *latent capacity* for the latter, just as we say that the oxygen, hydrogen, carbon, and nitrogen, which make up the organic substance termed muscular fibre, and which in that state or mode of combination possesses certain vital properties, possess also a *latent capacity* for combining in that mode of aggregation termed crystalline, and for the exhibiting the solubility, translucency, and other qualities of a salt, (all of which are totally opposed to its vital properties and cannot co-exist with them,) when united into the form of cyanate of ammonia. If we were only acquainted with those elements as they exist in organic compounds, their transposition into a crystalline salt would be almost as marvellous to us as the opposite change is now. If this latent organisability or vitality be admitted (as we conceive logical proof to have been given that it must,) as a property of a large proportion of what we call inorganic matter, is there any such wonderful difficulty in imagining that it may be brought into play in some other manner than by *the agency of a pre-existing germ?* We think not. But let further investigation, and more extended experience decide." A distinguished naturalist, in the article "Zoophytes," in *The Encyclopedia Britannica*, 7th edit., treating of the *entozoa*, thus observes:—"To explain the beginning of worms within the human body, on the common doctrine that all created beings proceed from their likes, or a primordial egg, is so difficult, that the moderns have been driven to speculate, as our fathers did, on their spontaneous birth; but they have received the hypothesis with some modification. Thus, it is not from putrefaction or fermentation that the *entozoa* are born, for both these processes are rather fatal to their existence; but from the aggregation and fit apposition of matter which *is already organised*, or has been thrown off from organised surfaces. Their origin in this manner is not more wonderful or more inexplicable than that of many of the inferior animals from sections of themselves. We think the hypothesis is also supported in some degree by the fact, that the origin of the *entozoa* is favoured by all causes which tend to disturb the equality between the secerning and absorbent systems." And, in Todd's *Cyclopædia of Physiology*, Dr. Carpenter, "ON LIFE," observes:—"No reasonable ground has yet been adduced for supposing that, if we had the power of bringing together the elements of any organic compound in their requisite state and proportions, the result would be any other than that which is formed in the living body." In the article, "*Generation*," in Todd's *Cyclopœdia of Anatomy and Physiology*, Dr. Allen Thompson states several considerations arising from analogical reasoning, which, he says, "Seem to him to show the balance of evidence at the side of the primitive production of the *infusoria*, the vegetation called *mould*, and the like."

Sir Thomas Watson, in his *Lectures on the Principle and Practice of Physic*, observes that—"The obscurity that hangs over the origin of some of the *entozoa* is not, indeed, the only, nor I think the chief, ground upon which the notion of spontaneous generation rests. You are probably aware that minute animalcules, so minute that most of them cannot be seen without a microscope, soon become abundant *in water wherein vegetable or animal matters* have been dissolved by infusion. Such animalcules are, therefore, called *Infusoria.* How do they come there?

There are two suppositions open to us. One is that they are formed by the fortuitous union of organic atoms contained in the infusion. The other is, that they proceed from *ova* or *germs* existing in the liquid, or floating always in the atmosphere, and ready to quicken whenever they light upon their proper element. That the ova of animals, which are themselves visible only by the aid of a microscope, should be absolutely invisible to us, is not surprising. Air, solar light and heat, and 'organic matter' in solution, being given, does animal (or even vegetable) life ever result? That is the question."* But

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*In September, 1867, having cleansed with boiling water a medium-sized glass bulb furnished with a long neck, I poured into it a quantity of pump-water sent to me for examination. This water, upon analysis, contained carbonate of lime and magnesia, free ammonia, and nitrogenous organic matter. The bulb holding the water was placed on a flower-stand in the window recess in my library, where it has since been exposed to the solar light and heat. The mouth of the long neck of the bulb was carefully tied over with closely-wove fine woollen cloth, in order to protect the water from all foreign substances, at the same time admitting the atmospheric air; the woollen cloth was immersed in boiling water, and dried in hot air, previous to using it.

In November following, first, monads made their appearance, rendering the water much less transparent;

the *experimentum crucis* has been made, and has answered both negatively and positively. However, Sir Thos. Watson, having reviewed the subject, concludes that :—" Upon the whole, we may reject the hypothesis of equivocal generation, and fall back upon the Harveian axiom, taken in its most extended

aggregations of shapeless cells, and some particles of chlorophyll, soon followed. Gas globules, attached to a colourless viscid protoplasm, at the lower part of the glass bulb, were next noticed. After some time, these globules, gradually ascending, brought to the surface and diffused through the water—not unlike a spider's web—this protoplasm. From this web-like albuminous substance animalcules were observed to present, and were, for some time, exceedingly active. They have disappeared, or are in a "still state"; and amœba in different forms are, at present, visible to the unaided eye, as are also many protophyta. Thus animal and vegetable life is plainly manifested.

On the same day, some of the same sample of water as above was poured into a stone jar which, being emptied of its contents (whiskey), was previously carefully cleansed with boiling water. Having perforated a cork with a red-hot iron wire of two lines diameter, and fitted a piece of tinfoil to the under part and circumference of it, the mouth of the jar was closed therewith. I next punctured the tinfoil, through the small hole in the cork, by means of a needle, and tied down on the corked mouth a doubly-folded piece of fine linen cloth. The jar, thus arranged, was placed in a cool part of the study. The water in this jar was assumed now to be in a conditiou similar to that of the water in the pump, from which it was only just sense, of *omne vivum ex ovo.*" Professor Owen also strongly discountenances the doctrine of organic creation by law—equivocal generation. He argues that the great tenacity of life possessed by some of the infusorial animalcules, as well as by most of the ova of

taken, with but one exception—the water under experiment could not acquire a *new supply* of any impurities.

After a few months in this specimen of the water were found numerous animalcules; and at the present the animalcules have disappeared, but have been succeeded by a great many *acari*, moving through the water, and so large that they are visible to the naked eye. I have recently removed this water from the jar, and it is now exposed to light and solar heat in the same situation as is the first sample.

On examination, I find that the water which was exposed, since 1867, to solar light and heat, as detailed, and in which vegetable and animal organisms appear, is *nearly free* from organic matter in solution; whereas that kept in the jar, from which light and heat were rigidly excluded, although containing *acari*, holds still in solution organic matter in much larger quantity than the other specimen of the same water which was exposed to light and solar heat.

From the facts exhibited, it may be a legitimate inference, that solar light and heat, and the presence of atmospheric air, greatly tend to eliminate organic matter from water, and that pump-water containing organic matter (from which light is necessarily shut out,) will not be much, if at all, improved by time, even were the cause or source of *all further pollution of the well disregarded,* or having been discovered might apparently be removed (?).

microscopic animals, increases the chance of their reaching their habitat, which "adds to the presumption against their spontaneous origin." It is asserted that "Spallanzani kept certain infusorial animalcules *four years* in a state of complete desiccation and apparent death; but they presently recovered life and motion upon being then moistened." He adopts the curious theory of "alternating generations," and states his belief in the probability that "the *cystic* family of *entozoa* were the larvæ of the whole *cestoid* family." "The young of most of the *entozoa* undergo metamorphoses. Certain *entozoa*, the parasites of certain animals, have been ascertained to present merely a transition state of other *entozoa*, the parasites of certain other animals." The difficulty belonging to the question of oviperous generation is, it is thought, thus materially lessened. It is also assumed that "few of the innumerable *ova* produced by the *entozoa* and other creatures, can reach *the proper element* for hatching into the *cystic* state, and fewer still the remote place of their final mutation." The Professor further remarks that "many of the minute ova, in large towns and cities, must eventually find their way into streams and potable water, for whose microscopic inhabitants—or for terrestrial creatures under other circumstances—they probably furnish food."

In the *British Medical Journal* for September, 1869, will be found, under the heading "THE ORIGIN OF LIFE," the details of carefully conducted experiments, and some able arguments tending to prove that the living organisms which are found to exist in water containing organic matter — even after it has undergone, first, a process of boiling for some hours, then the vessel being carefully hermetically sealed to exclude the air, at the end of six days making their appearance—"would seem to make it almost absolutely conclusive that such organisms must have been newly evolved, since it would seem quite impossible that any of them, or of their germs, could have braved and survived the conditions to which the different media had been submitted." The almost conclusive experiments of M. Pouchet go far to establish the fact "that a so-called 'spontaneous generation,' or rather a new evolution of life, could take place out of dead organic matter;" and clearly point to the probability that *monads* do not increase and multiply by a process of fission—and, indeed, if they did, we should still have to inquire as to the mode of origin of these primary monads—so that we are driven to presume that they must either proceed from monad germs, which are themselves of perfectly inappreciable size, and of an utterly unknown mode of origin, or else we must presume that they are directly and newly evolved out of the organic matter in solution, just as we may see that ciliated infusoria are evolved out of dead or motionless organic granules. We are thus reduced to two alternatives, neither of which seems capable of proof. Either we must assume the existence of monad germs too minute to be capable of appreciation, teeming everywhere—metaphysical germs we may almost call them, as difficult of recognition as those of Bonnet—or we must believe in the possibility of this new evolution of monads out of organic matter in solution." And, again, Dr. Carpenter, in his work on the microscope, thus observes:—"Like the vegetable cell, that of the animal very commonly multiplies by duplicative subdivision; and it also (especially among Protozoa) may give origin to new cells, by the breaking up of its contents into several particles; but new cells are not unfrequently to be met with, especially in the nutritive fluids of such animals as possess a distinct circulation which have not directly originated in either of these modes from a previously existing cell, but which *have been developed by a process of free cell-formation*—namely, by the aggregation of organic molecules, floating in these fluids, into little masses, of which the external particles coalesce into a membraneous cell-wall, whilst the interior liquify into cell contents. This can only take place, however, in a liquid which has undergone elaboration in the interior of a highly-organized living body."

A very serious form of stomach affection, in which has been discovered a new form of vegetable life, is of modern diagnosis. This vegetation is called *sarcina ventriculi*, and is presumed to be one of the confervoid algæ, or a "blanched form of fresh-water algæ." It is found in the stomach; "where it gets by means of the water used in drinking;" and germinating there, is, frequently in considerable quantities, observed among the ejected contents.[*] If we are to give credence to a large mass of scientific evidence, ague, diphtheria, thrush, favus confertus, arise from infecting particles belonging to the *vegetable*, and variola, vaccinia, pyœmia, from the *animal*, kingdom. The *modus operandi* and the nature of these particles have not, however, as yet been determined with accuracy.

[*] A case of this sort presented itself to me a few months since:—

Mrs. B., aged 42 years, pale and haggard expression of countenance, great emaciation and much debility, suffers severe pain at the epigastrium immediately after eating solid food, which continues until the food is rejected.—Finds difficulting in swallowing solids, and thinks that they are always arrested in the passage; liquids are occasionally difficult to swallow, and are sometimes rejected by vomitting. Stricture of the œsophagus and malignant disease of the stomach were suspected. The introduction of the tube of a stomach-pump was effected without interruption or difficulty, or production of pain to the patient. Some turbid mucus was brought up from the stomach, which, on examination under the microscope, contained a large quantity of *sarcina ventriculi.*

Acid carbolic, pulv. aromat. bismuth. alb. in full doses were prescribed, in powders, to be taken twice daily, and a mixture of sulphite soda in infusion columbo, once daily. At the end of a week my patient was comparatively well. The mixture of sulphite was continued, in increased doses, for a few weeks, when the patient became perfectly restored to her ordinary health.

It has been frequently remarked that potable water containing organic matter is at times more deleterious. This occurs, not that the organic matter is of a specially virulent kind or of a peculiar quality, but because it then happens to be in a state of activity. It is a well-ascertained fact that monads, globules, reproductive cells, and spores — all have periods of repose, or rather a still state, in which their presence in the animal economy is comparatively harmless, and so soon as vital motion is aroused through atmospheric or other influence, the result is always deleterious, and insect life becomes a cause of disease.

"Peculiar microscopic animalculæ constantly exist in the characteristic 'rice-water' discharges of persons affected with cholera, and also in the atmosphere and water of infected places"—that observation forced itself upon me in 1849. During the epidemic of that year my mind was very much occupied with the investigation of cholera; and I published a treatise on that disease in 1853, in which I ventured to discuss the question of epidemic influence, and express a surmise that the presence of organic life in those instances was an effect of the *morbus celi*—not a cause. It further suggested itself that those facts tended in the direction to prove the abnormal condition of the "cosmic forces" during the prevalence of the epidemic influence. We know that certain physical conditions are indispensable for the developing of these metaphysical or creative laws; and possibly the association of the requisite stipulations for organic creation exists in the body of a person affected with cholera, and also in the water of infected places if it be impregnated with nitrogenous organic matter.

At the thirty-seventh annual meeting of the *British Medical Association*, held on the 28th July, 1869, at Leeds, Sir William Jenner, in his "*Address on Medicine*," having alluded to the fact that the progress of medicine as a science is unquestioned, proceeded to show that its progress as an art should be unquestioned also; and referring to the position of the "healing art" in the time of his own youth—having regard to the four cardinal aims of the practitioner, viz.:—1st, to prevent disease; 2nd, to cure disease; 3rd, to prolong life; 4th, to alleviate suffering—he maintained that in all these respects the practical progress of medicine in the present day was second to that of no other branch of knowledge. After illustrating this position by facts that were familiar to his hearers, but that would not in the same way appeal to the knowledge of the general public, he came at last to deal with matters within the cognizance of all:—"In illustration of the advance made in preventive medicine, I will adduce the firm establishment of the fact that drinking water is one of the greatest agents in the spread of two of the most fatal acute diseases of the present time—namely, cholera and typhoid fever. In the ten years ending 1866, 21,848 died from cholera in England and Wales, and 192,562 from fever. From the Registrar-General's returns it is not possible to say precisely how many of the 192,562 persons died from typhoid fever; but, seeing that this is the endemic fever of our country, and that typhus fever prevails as an epidemic only, and that in limited localities and for a short time, we shall be within the limits of high probability when we say that 150,000 persons died of typhoid fever during the ten years in question, and that in no one year of the ten did less than 10,000 persons die of that disease. Now, with reference to cholera, the special facts collected by Dr. Snow prove that one of the great agents in the diffusion of cholera was drinking water; that every virulent local outbreak in a limited district was clearly coincident with the pollution of the drinking water supply of the district; and that persons living at a distance, if by accident they drank of the polluted water, suffered as certainly as if they dwelt in the district specially affected. The conclusion which follows from the facts collected by Dr. Snow is that, the conditions existing, be they atmospheric or other, which determine the epidemic disposition to cholera, the presence of minute portions of cholera excreta in the water supplied to a district for drinking purposes will be followed by an outbreak of cholera in that district. Careful investigations into the circumstances attending local virulent outbreaks of cholera during the last epidemic have proved the truth of that conclusion. I will refer to two such investigations only—namely, Mr. Netter Radcliffe's admirable researches into the relation between the water supply and the spread of cholera in London, and to Dr. Bellot's most conclusive observations on impure water as a cause of cholera in Hollard. Dr. Snow's investigations traced special individual cases and local outbreaks to one existing cause. Mr. Radcliffe's researches bear especially on the influence of the polluted water in determining excess of mortality in a large district of a great city. Dr. Bellot's facts show that those towns and those parts of a town in Hollard in which there was the greatest facility for the contamination of the water supply by cholera dejections were those which suffered by far the most severely. The spread of typhoid fever by contamination of the drinking water supply is, if possible, less disputable than is the spread of cholera by the same means. Every new investigation has added new proof to the strong presumptive evidence afforded by Dr. Flint's cases. Solitary cases, outbursts confined to single houses, to small villages, and to parts of large towns—cases isolated, it would seem, from all sources of fallacy—and epidemics affecting the inhabitants of large though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fæcal matter, but especially of the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease. The proof, then, seems complete that a large proportion of those who drink water containing a minute quantity of the excreta from a person suffering from cholera or typhoid fever, will suffer cholera or typhoid fever. These diseases, like smallpox, scarlet fever, and measles, occur as epidemics, owing to causes of which we know little or nothing; but, when epidemic—unlike smallpox, scarlet fever, and measles—a local outbreak will be determined by the impurity of the drinking water. Had the water supplied to the east of London been as free from organic impurity as was that supplied to the west of London, the death-rate from cholera at the east would only have been a little larger than was the death-rate at the west of London. Had the drainage and water-supply of Winterton, Terling, and Guildford, been what modern medicine has shown that for health purposes they should have been, those places would not have suffered the terrible outbreaks of typhoid fever of which the medical officer of the Privy Council gives such full details in the 10th volume of his inexpressibly valuable reports. The persons who died at these places from typhoid fever, and a large proportion of those who died at the east of London from cholera, were as certainly killed by the water they drank, and killed without need, as if the water supplied to them had been contaminated by arsenic. I am sure we all agree with the most distinguished medical officer of the Privy Council that 'the distribution of fouled water by the Guildford Board is as proper a case for judge and jury, or action for damages by any of the 500 people who had typhoid fever in that town, as any case in which a railway collision brings some score of passengers to harm; and the fact that these water purveyors gave typhoid fever to their customers would be brought home to their consciences, and be suggested as a warning to other water purveyors, in a far more conclusive and effective manner by such legal proceedings than it can be by any departmental statistics and remonstrances.'"

In thus discussing the subject before us, I do not think it necessary to express an opinion upon the relative ability of the arguments adduced in support of the suppositions or theories of the origin of vegetable and animal life, as the views put forward by either party present to us the fact that existence of "organic matter" in solution is an essential condition, which the requisite combination of organic molecules demands, as well as the development of germination and generation; and as the minutest *microscopic ova* requires the presence of germination to enable generation to fully manifest itself, so does the *minutest germ* demand "organic matter." We see, then, that the fundamental basis of both hypothesis is the presence of "organic matter."

I now finally submit the preceding evidence derived from explorers in the domain of physical science, who have exhibited, in abundance, proofs, which, when justly appreciated, must convince of the truth of the proposition here advanced—that the habitual use of potable water, in which "organic matter" is contained, is calculated not only to induce the pre-disposition state of the system, but to *actually create disease.*

In conclusion, I hope that it may not be deemed irrelevant to offer a few remedial suggestions for the serious consideration of our corporate authorities.

Doubtless one of the most useful of the various duties imposed upon municipal bodies, is that of enforcing the observance of sanitary laws. Cleanliness, ventilation, and pure water, are in the present day held to be of nearly equal potency in the preservation of health. Therefore there cannot be the least uncertainty but that a prudent and moderate outlay incurred in procuring a supply of pure water will meet with the entire approval of a discriminating community, who must perceive in such, a work of public utility, and appreciate it accordingly.

I have ascertained that "organic matter" may exist in certain wells of a town and the water be pure in others. For instance, those at one side of a street might be pure, and the contrary at the other side. Again, the pumps located in a certain direction, as regards the geographical position of an intramurial burial ground, may contain the morbific matter, whilst those more *immediately adjacent*, but in a direction geographically different, might be free from the impurity. Other instances present, where the wells not remote from a burial-ground of greater elevation than the pump are found to be impure. These and other facts ostensibly indicate substratal currents dependent upon the geological formation of the locality, perhaps rendered infectious by blending with the rain-fall, which percolating through the burial-ground, holds in solution "organic matter" thus obtained. In few cases leakage from specific sources of decomposition point to the cause of the pollution.

We now perceive how the presence of "organic matter" can be proved to exist in the water from certain wells of a town, and its inhabitants be kept perfectly unconscious of the fact; and we see why potable water, thus rendered impure, is deleterious to the health of those who use it for drinking purposes. The mode of ascertaining its existence is, I trust, simplified, and made available to all, so that henceforth the procuring of pure water for corporate and other towns must necessarily engage more of the attention and care of local authorities.

As the first step towards procuring a pure water-supply, we should not hesitate to declare for the unqualified, the absolute rejection of that from wells or pumps placed in the streets of large towns. A full supply of potable water, perfectly pure, can, in most Irish towns, be readily obtained from neighbouring running streams, and at inconsiderable expense, by means of pipes to common public fountains, to be erected in the most convenient localities within the town or city. The source should be at a distance from the supply, and at an elevation, to insure it from all possible risks of pollution. To avoid impurities from much vegetable decomposition the stream ought to be small, but, of course, sufficient for a full supply; and, as previously observed, that water which "passes rapidly over a rough pebbly or selicious channel" ought to be selected. ANSTED remarks:—"It should be remembered that a certain amount of exposure to the air is useful and almost essential to give water its valuable properties for household purposes." And MILLER, in his work on "Chemistry," thus states:—"Running water is endowed with a self-purifying power of the highest importance. The continual exposure of fresh surfaces to the action of the atmosphere promotes the oxidation of the organic matter, and if the stream be unpolluted by the sewage of a large town, this natural process is fully adequate to preserve it in a wholesome state."

Some few years since the Legislature were induced to pass a law for compulsory vaccination, with the view to limit the origin and spread of a single but repulsive disease. On the same principle—to arrest the spread of many preventible diseases—it should not be difficult to influence the Government to pass a compulsory measure to enable municipal bodies to provide an ample supply of pure water for the use of the inhabitants of their municipalities. In this way a very great obstacle, at present almost prohibitory to the action of our local authorities, would be removed.

But I am aware that an outcry can at any time be raised, on the plea of "over taxation," sufficient to stay the most practical; and it may, nevertheless, be often observed that the heaviest rate-payers are themselves the first to complain of inaction on the part of those on whom they have conferred corporate honours.

Legislative enactments of recent dates give ample powers to local boards to efficiently perform the business for which they have been called into political existence; and in periods of panic at the approach or presence of epidemic or other disease—although a few impassioned efforts seldom effect much—we must admire the laudable energy with which officials insist upon the observance of cleanliness and ventilation; yet, ignorant of the equal importance of pure water, and unconscious of the fact that deleterious water is supplied for the use of the people, nothing is or could be heard of the matter.

We know that rates for supplying the municipality with pure water are levied, and it may be mandatory that a sufficiency should be furnished. It, therefore, is obviously necessary on the part of all corporate councils to consider the position in which they, or any of them, might be placed if to their knowledge an impure water supply be allowed to exist within their municipality.

I am one of those who believe that there are little grounds to justify the taunts we so often hear, that corporate bodies, having the power, usually lack the will to aid in any improvement of *general utility*, and are mere political institutions destined to retard the spirit of progression that marks the age in which we live.

Upon public grounds, I would be glad that the general Press of the kingdom could be urged to the discussion of the remedial and practical portion of the question.

We should not cease to agitate until the Government pass a law making it imperative upon all local public bodies that every city, town, hamlet, and district in the kingdom shall be supplied with potable water of that character approved by modern science; and that no town of any extent or importance will be permitted to be dependent for its water-supply upon the perilous — if not polluted—sources of wells or pumps in the streets, flowing from a soil and sub-soil inevitably loaded with impurities. In order to enforce effective sanitary laws, mandatory legislation is not only justifiable, but indispensable. It is justifiable as providing "means of limiting the origin and spread of preventible diseases;"—it is indispensable as, if not suppressing, rendering futile the cry of "ruinous taxation," always so confidently relied upon by factious opposition to impede all useful projects of improvement; and, let us hope that AS COMPULSORY VACCINATION HAS ERADICATED SMALLPOX, SO SHALL COMPULSORY SANITARY-LAWS EXTINGUISH EPIDEMIC VIRUS.

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